US012116918B2

(12) **United States Patent**
Akyildiz

(10) **Patent No.: US 12,116,918 B2**
(45) **Date of Patent: Oct. 15, 2024**

(54) **EXHAUST SYSTEM AND COMPONENTS THEREOF**

(71) Applicant: **ECC TEC MSJ INCORPORATED**, Boca Raton, FL (US)

(72) Inventor: **Saban Akyildiz**, Boca Raton, FL (US)

(73) Assignee: **ECC TEC MSJ INCORPORATED**, Boca Raton, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 18 days.

(21) Appl. No.: **18/512,403**

(22) Filed: **Nov. 17, 2023**

(65) **Prior Publication Data**

US 2024/0093627 A1 Mar. 21, 2024

Related U.S. Application Data

(63) Continuation of application No. 18/267,261, filed as application No. PCT/US2022/040366 on Aug. 15, 2022.

(Continued)

(51) **Int. Cl.**
F01N 3/20 (2006.01)
B01D 53/86 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F01N 3/2013*** (2013.01); ***B01D 53/8696*** (2013.01); ***B01D 53/9431*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B01D 53/8696; B01D 53/9431; B01D 53/9495; B01D 2258/01; B01D 2258/02;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,956,614 A 5/1976 Hervert
4,276,066 A 6/1981 Bly
(Continued)

FOREIGN PATENT DOCUMENTS

CN 2597684 Y 1/2004
CN 205948865 U 2/2017
(Continued)

OTHER PUBLICATIONS

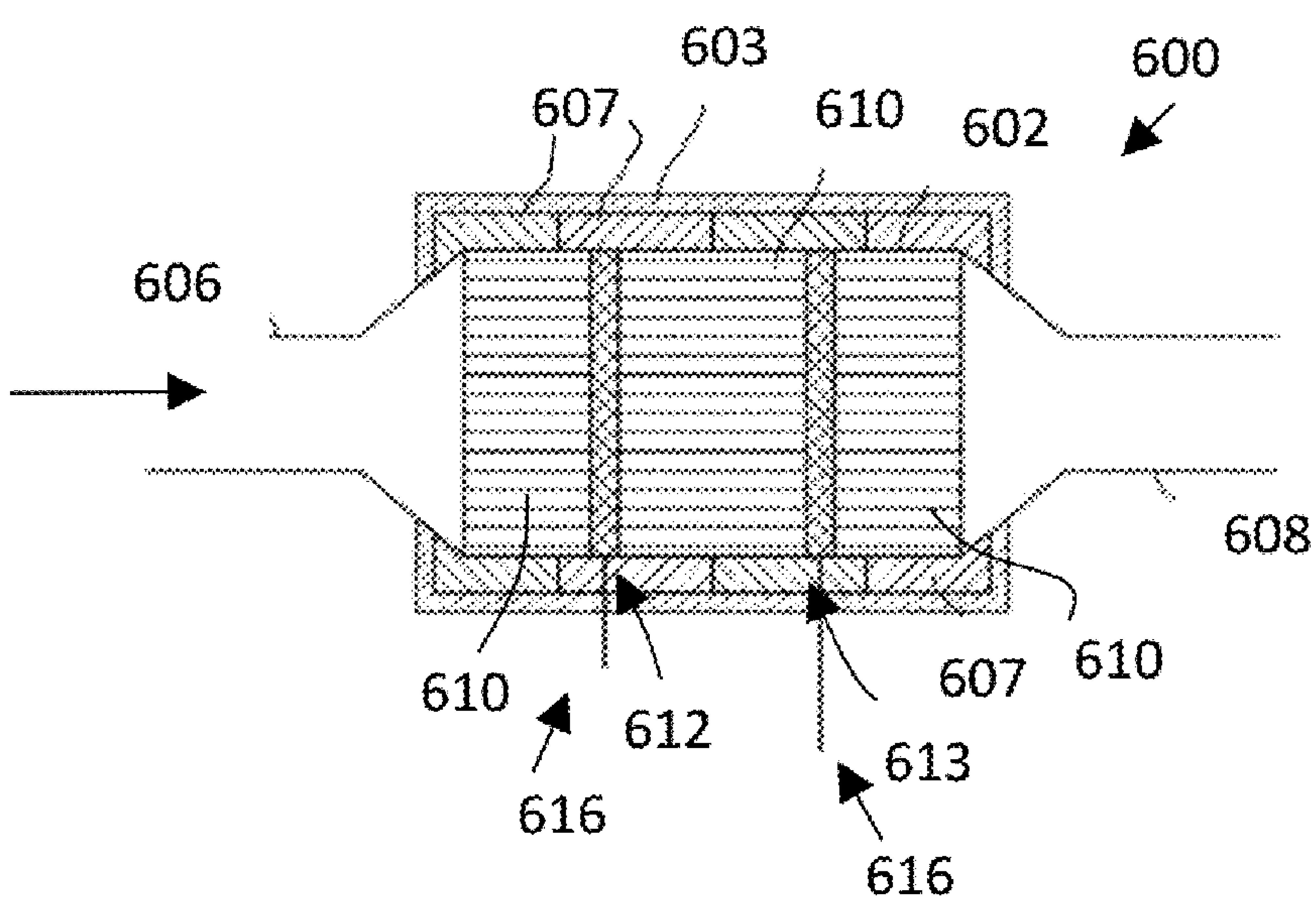
U.S. Appl. No. 18/209,780, filed Jun. 14, 2023.
(Continued)

Primary Examiner — Dapinder Singh
(74) *Attorney, Agent, or Firm* — Dentons US LLP

(57) **ABSTRACT**

A heater for an exhaust system that includes a housing having a connector coupled to the exterior thereof, a first terminal and a second terminal that are each disposed to the interior of the housing and electrically coupled to the connector, a heating element coupled to the first and second terminals, a heating wire coupled to the first and second terminals, and a plurality of heating rods inserted into the heating element to conduct heat from the heating wire throughout the heating element, wherein the connector receives power from an external power supply to supply electrical current to the heating element and the heating wire and wherein at least one of the heating rods supports the heating wire. The combination of elements are configured to heat and disrupt the flow of exhaust gases and aid in removing and/or reducing toxic gases and pollutants from the exhaust system.

33 Claims, 36 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 63/233,019, filed on Aug. 13, 2021.

(51) **Int. Cl.**
B01D 53/94 (2006.01)
F01N 3/035 (2006.01)
F01N 3/28 (2006.01)
F01N 13/18 (2010.01)

(52) **U.S. Cl.**
CPC ***B01D 53/9495*** (2013.01); ***F01N 3/035*** (2013.01); ***F01N 3/206*** (2013.01); ***F01N 3/208*** (2013.01); ***F01N 3/2892*** (2013.01); ***F01N 13/1805*** (2013.01); *B01D 2258/01* (2013.01); *B01D 2258/02* (2013.01); *F01N 2610/1406* (2013.01); *F01N 2610/1453* (2013.01); *F01N 2900/1602* (2013.01)

(58) **Field of Classification Search**
CPC F01N 3/2013; F01N 3/208; F01N 3/0892; F01N 3/2066; F01N 3/035; F01N 3/023; F01N 13/1805; F01N 13/009; F01N 9/00; F01N 2610/1406; F01N 2610/1453; F01N 2900/1602; F01N 2900/1404; F01N 2900/1811; F01N 2240/16; F01N 2240/20; F01N 2560/06; Y02A 50/20; Y02T 10/12; Y02T 10/40
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,450,681	A	5/1984	Sato	
4,945,721	A	8/1990	Cornwell et al.	
5,063,029	A	11/1991	Mizuno et al.	
5,234,668	A	8/1993	Harada et al.	
5,264,186	A	11/1993	Harada et al.	
5,423,904	A	6/1995	Dasgupta	
5,465,573	A	11/1995	Abe et al.	
5,569,455	A *	10/1996	Fukui	B01J 35/33 422/174
5,582,805	A	12/1996	Yoshizaki et al.	
6,585,940	B2	7/2003	Abe et al.	
8,309,032	B2 *	11/2012	Plati	B01D 53/9454 422/177
9,383,119	B2 *	7/2016	Kida	F24H 9/02
11,149,607	B2	10/2021	Akyildiz	
11,187,131	B2 *	11/2021	Brunel	F01N 3/2857
11,628,401	B2 *	4/2023	Beall	H05B 3/12 219/202
2001/0043890	A1	11/2001	Son	
2002/0053283	A1	5/2002	Akyildiz	
2004/0118111	A1	6/2004	Covit	
2006/0204408	A1	9/2006	Son	
2009/0074630	A1 *	3/2009	Gonze	F01N 13/009 422/174
2011/0162348	A1 *	7/2011	Kim	F01N 13/009 60/303
2013/0061576	A1	3/2013	Gonze et al.	
2017/0218823	A1	8/2017	Crawford	
2017/0226909	A1	8/2017	Hirth et al.	

FOREIGN PATENT DOCUMENTS

CN	206762544		12/2017
DE	102009014371	A1	9/2010
EP	153157		8/1985
EP	967174		12/1999
EP	1967712		9/2008
GB	2512845		10/2014
JP	2009097359	A	5/2009
WO	9421900		9/1994
WO	52309		9/2000
WO	0157370		8/2001
WO	2017198292		11/2017

OTHER PUBLICATIONS

Mohit A. Bagul et al., "Emission Reduction using Magnetic Pollution Filter", International Journal of Innovative Research in Science, Engineering and Technology, vol. 5, Issue 7, Jul. 2016.
Ali S. Faris et al., "Effects of Magnetic Field on Fuel Consumption and Exhaust Emissions in Two-Stroke Engine", Energy Procedia, vol. 18, pp. 327-338, 2012.
Karthik Dhayakar et al., "Effect of Twin Sparkplug in Two Stroke IC Engine", International Journal of Science and Research (IJSR), vol. 4, Issue 2, pp. 2147-2153, Feb. 2015.
Adel Mahmmod Salih et al., "The effect of magnetic field on the boiler performance fueled with diesel", International Journal of Scientific & Engineering Research (IJSER), vol. 7, Issue 2, pp. 406-410, Feb. 2016.
H. R. Jackson et al., "Catalytic NOx Reduction Studies", SAE Technical Paper, 730568, 1973, doi: 10.4271/730568.
International Search Report and Written Opinion of Application No. PCT/US2019/063387 dated Feb. 7, 2020.

* cited by examiner

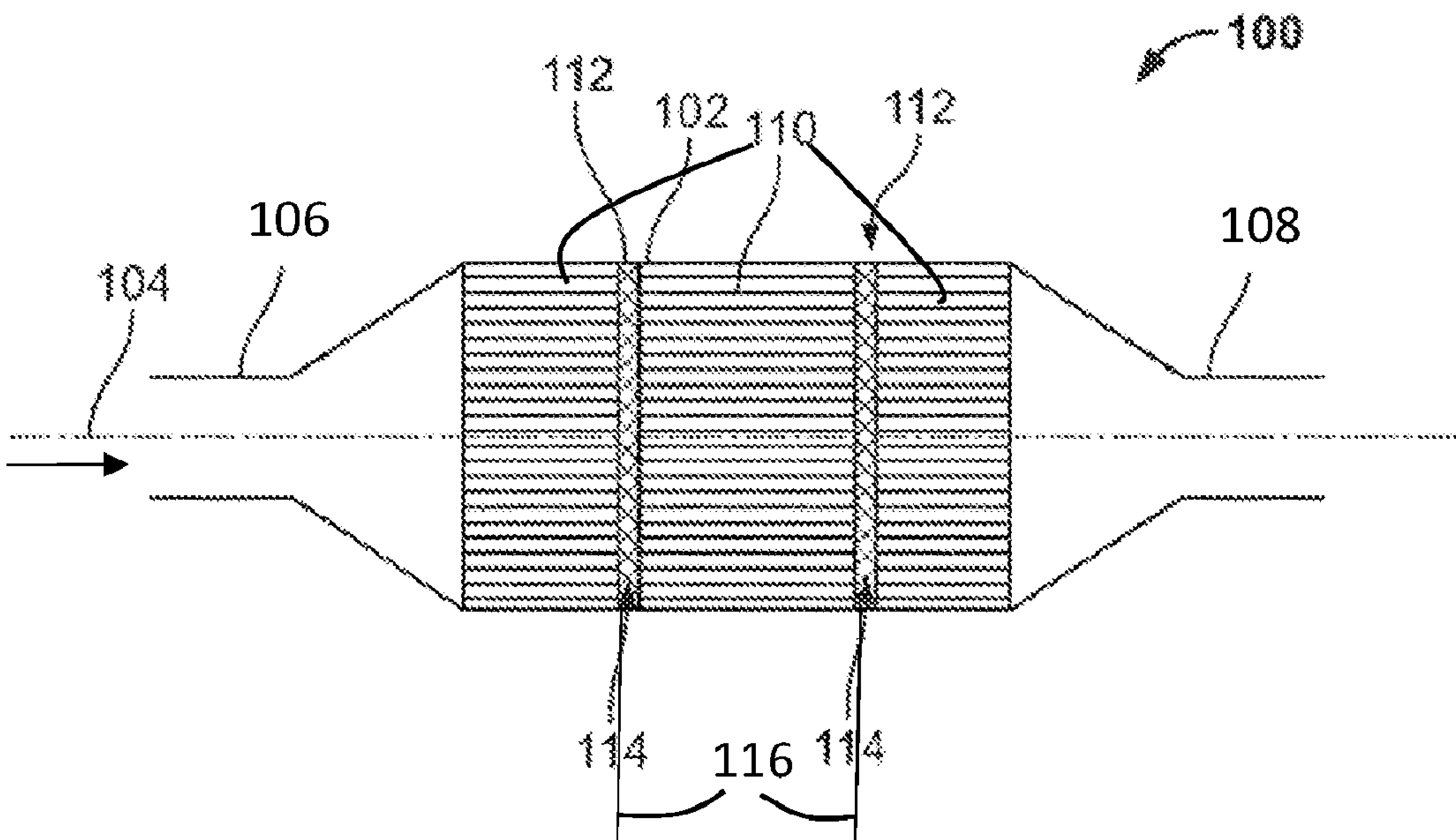


FIG. 1

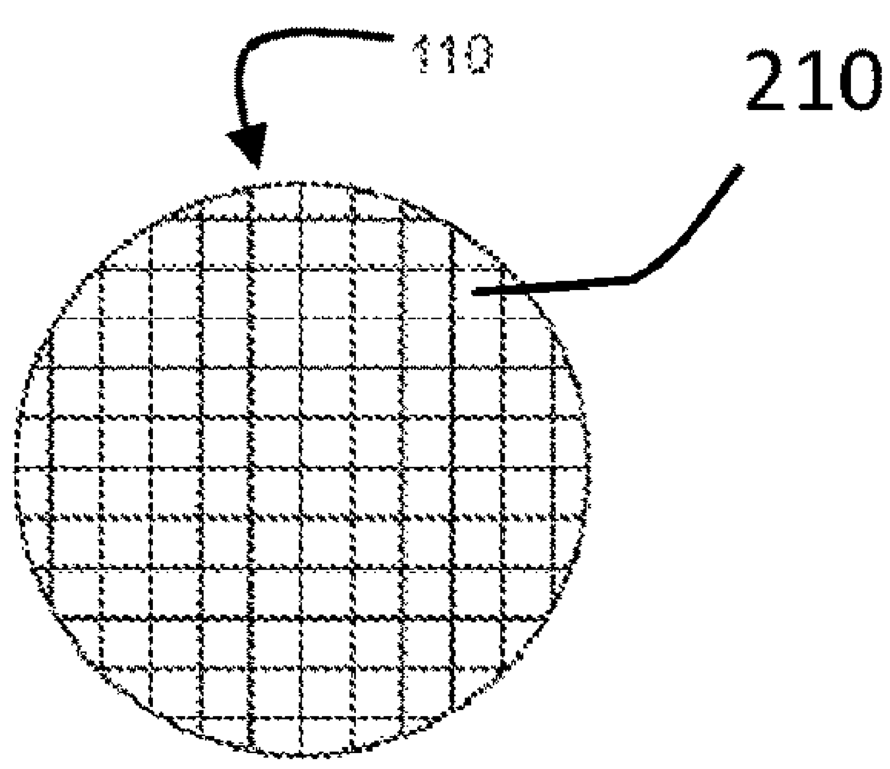

110
210

FIG. 2A

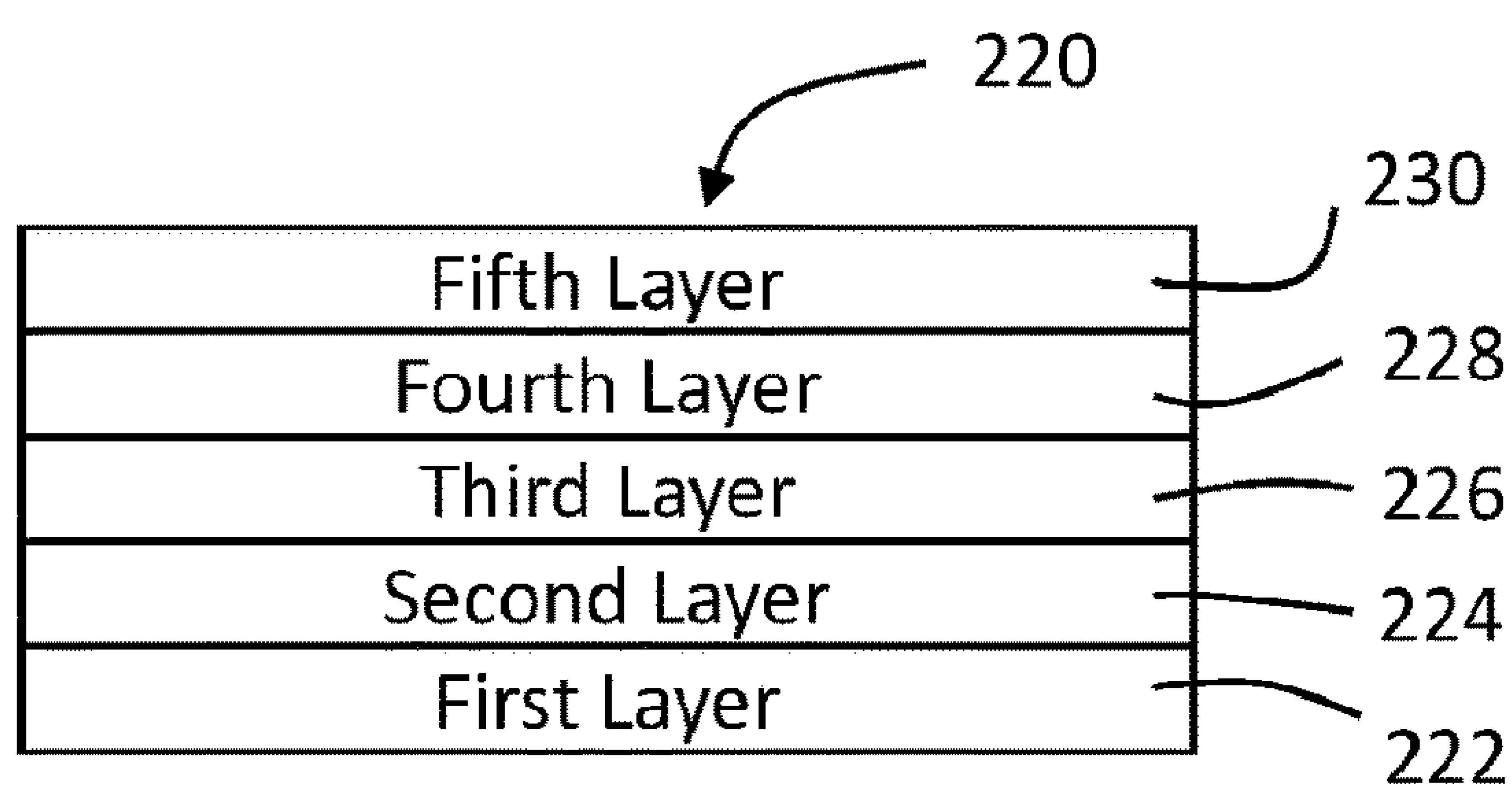

220
230
Fifth Layer
228
Fourth Layer
226
Third Layer
224
Second Layer
222
First Layer

FIG. 2B

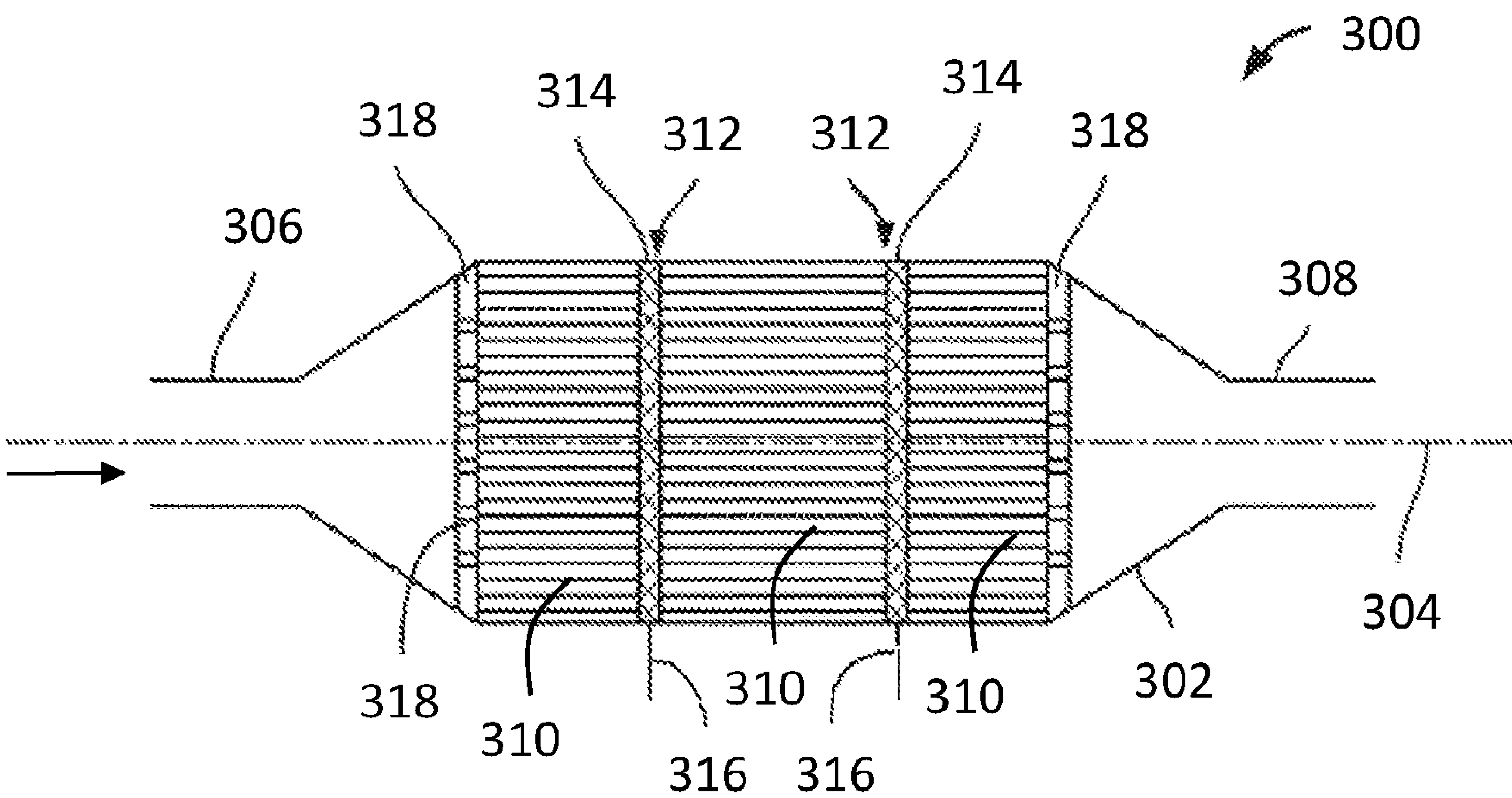

300
314
314
318
312
312
318
306
308
304
318
310
310
310
302
318
310
316
316

FIG. 3

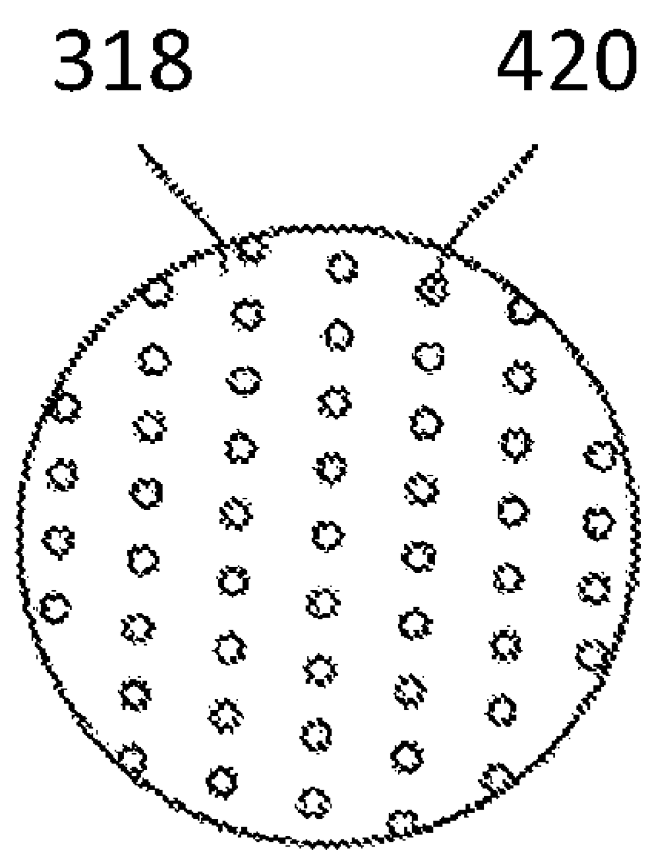


FIG. 4A

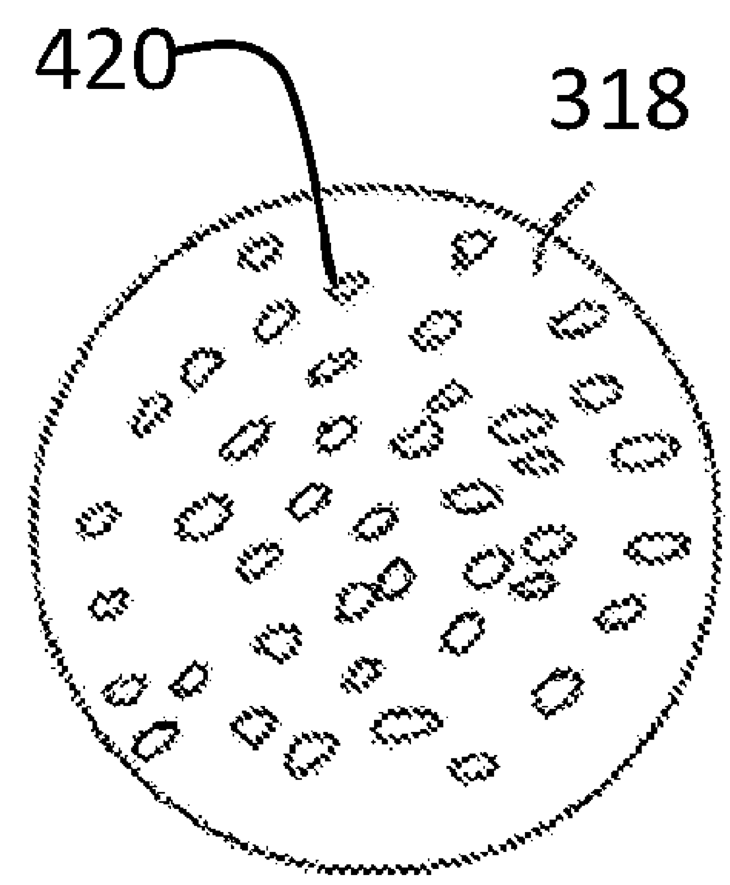


FIG. 4B

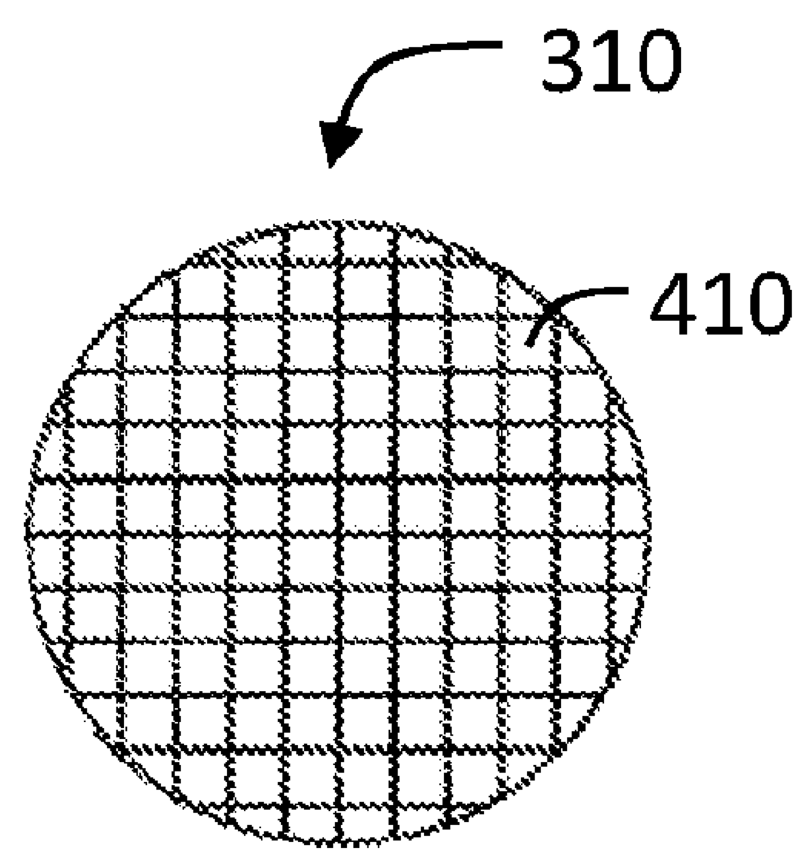


FIG. 4C

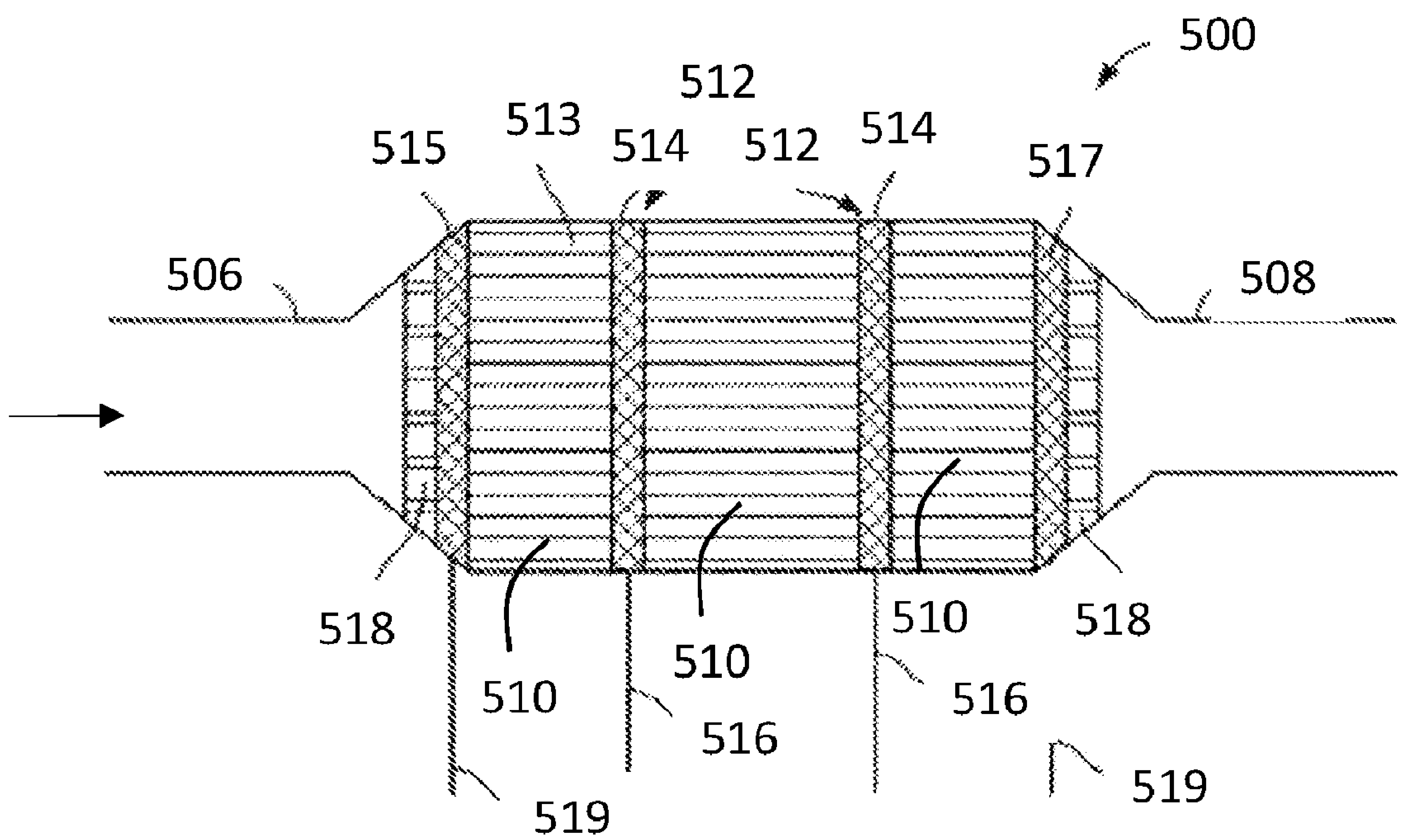

500
512
513
515
514
512
514
517
506
508
518
510
510
510
518
516
516
519
519

FIG. 5

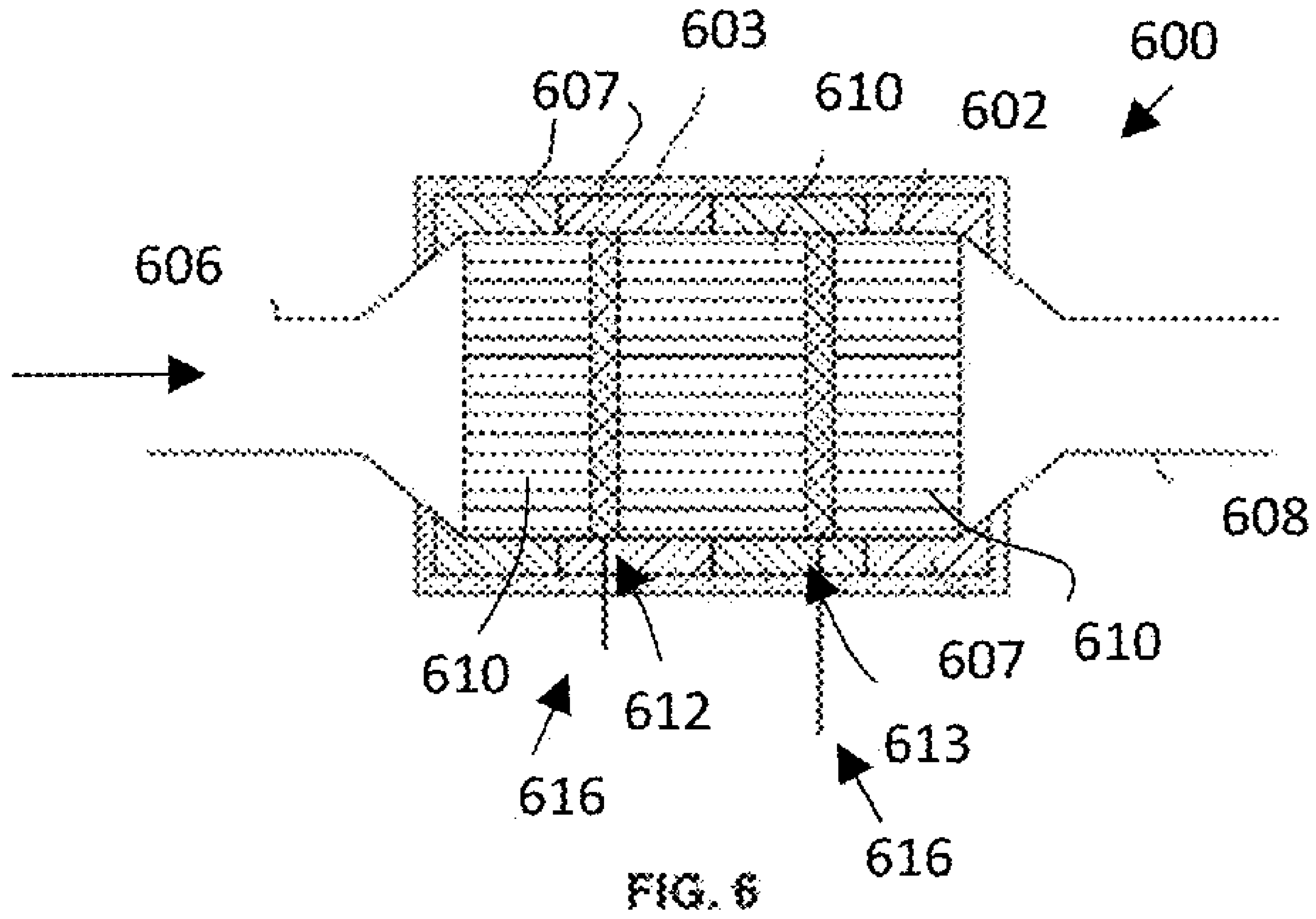

603
600
607
610
602
606
608
610
612
607
610
616
613
616

FIG. 6

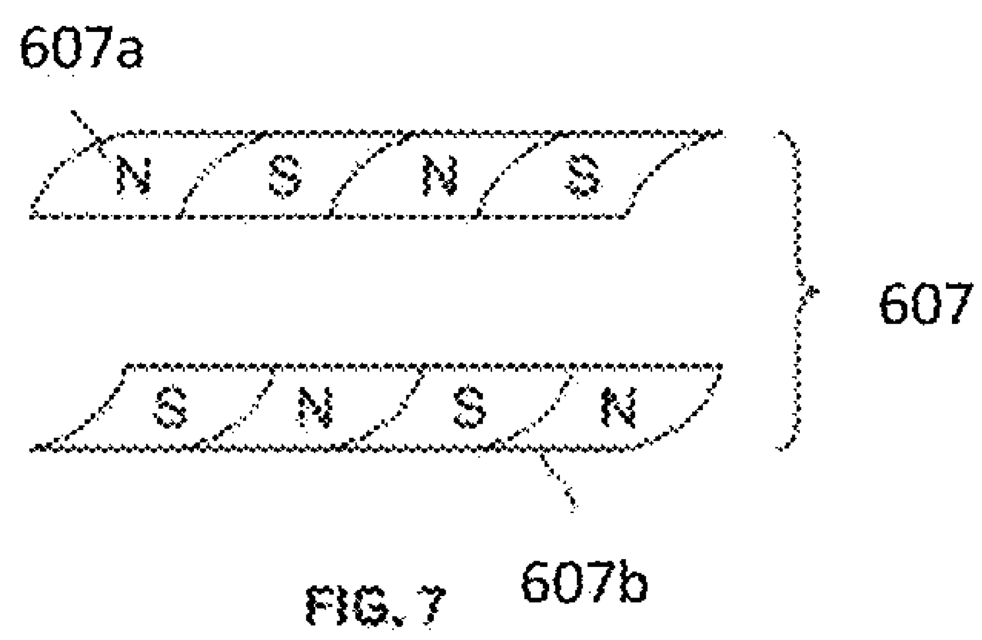

607a
N
S
N
S
607
S
N
S
N
607b

FIG. 7

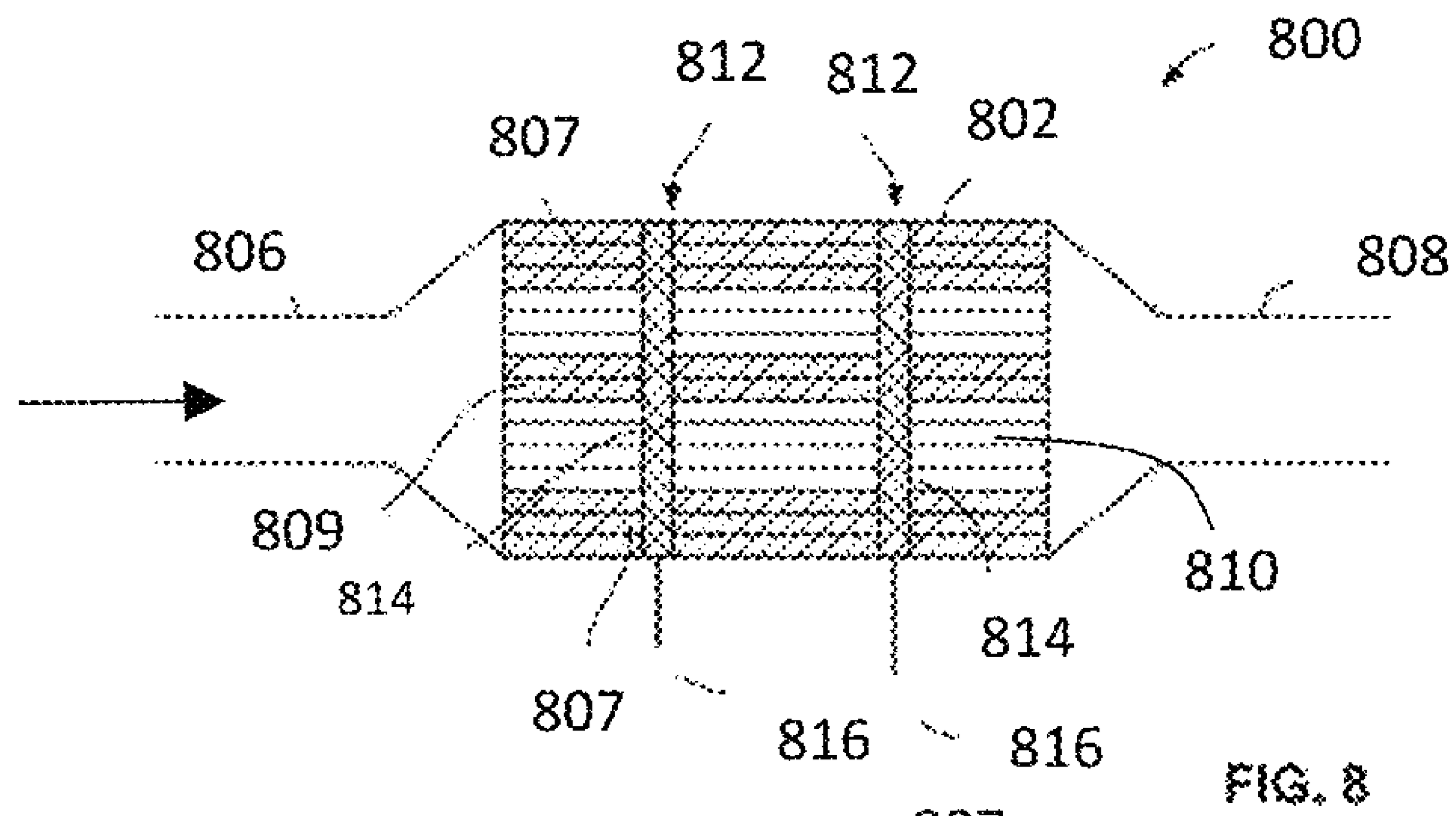


FIG. 8

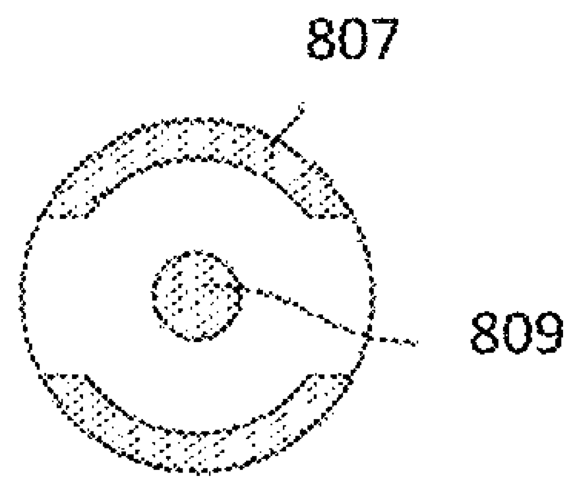


FIG. 9A

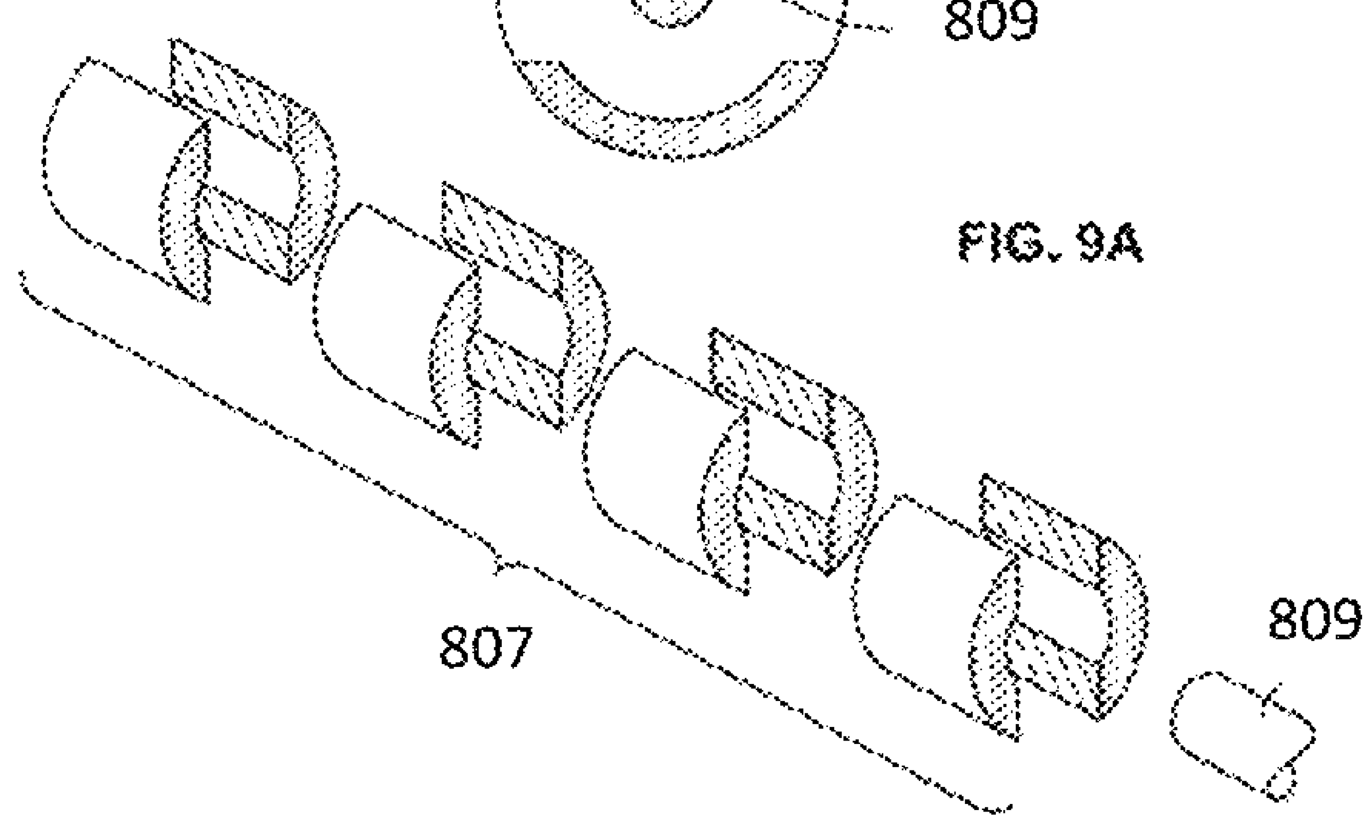


FIG. 9B

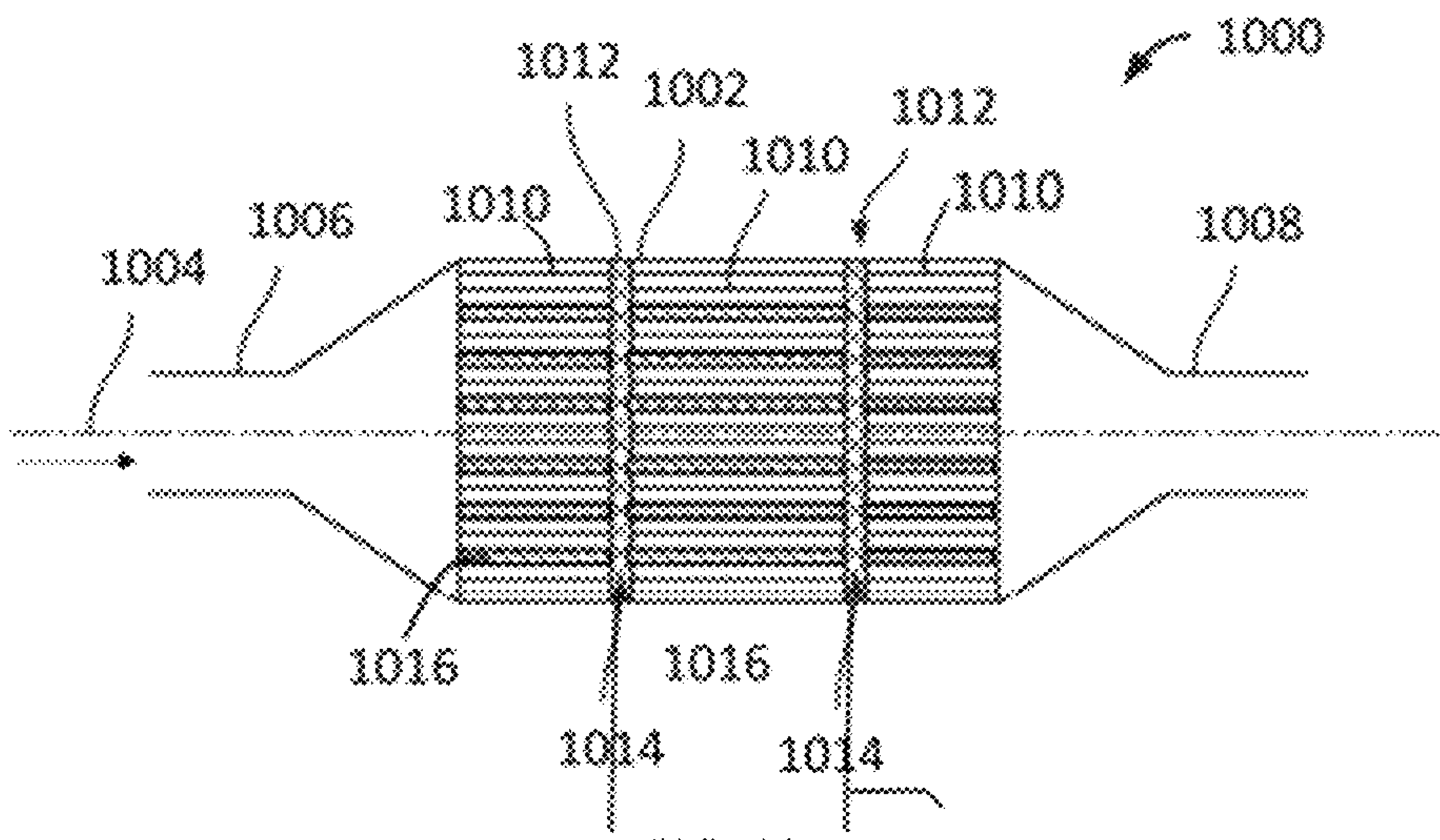

1000
1012
1002
1012
1010
1010
1010
1006
1008
1004
1016
1016
1014
1014
1018

FIG. 10

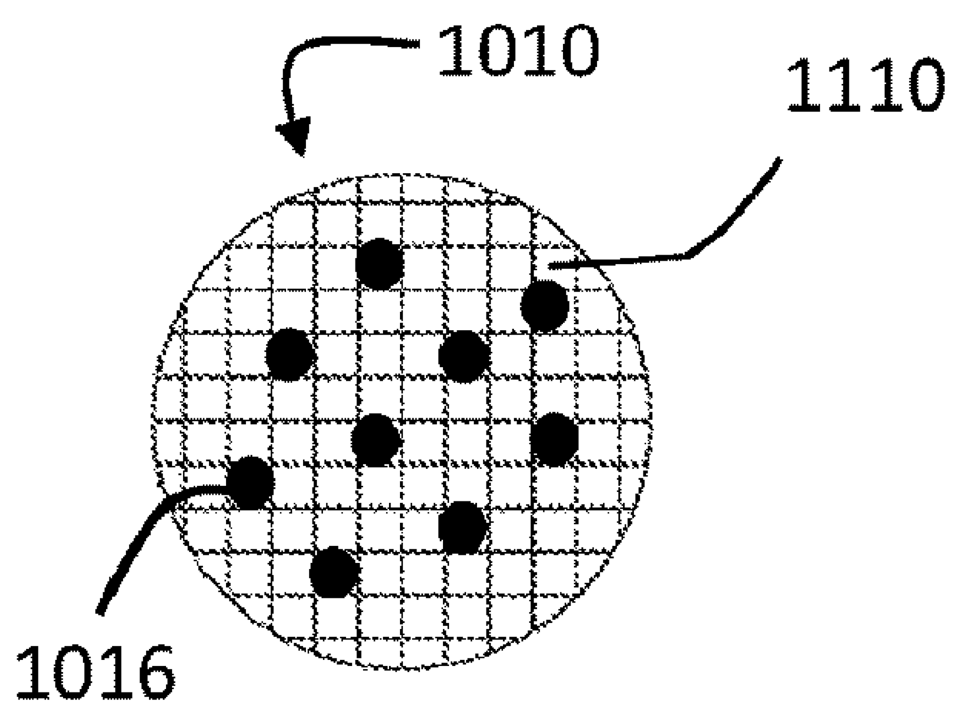


FIG. 11A

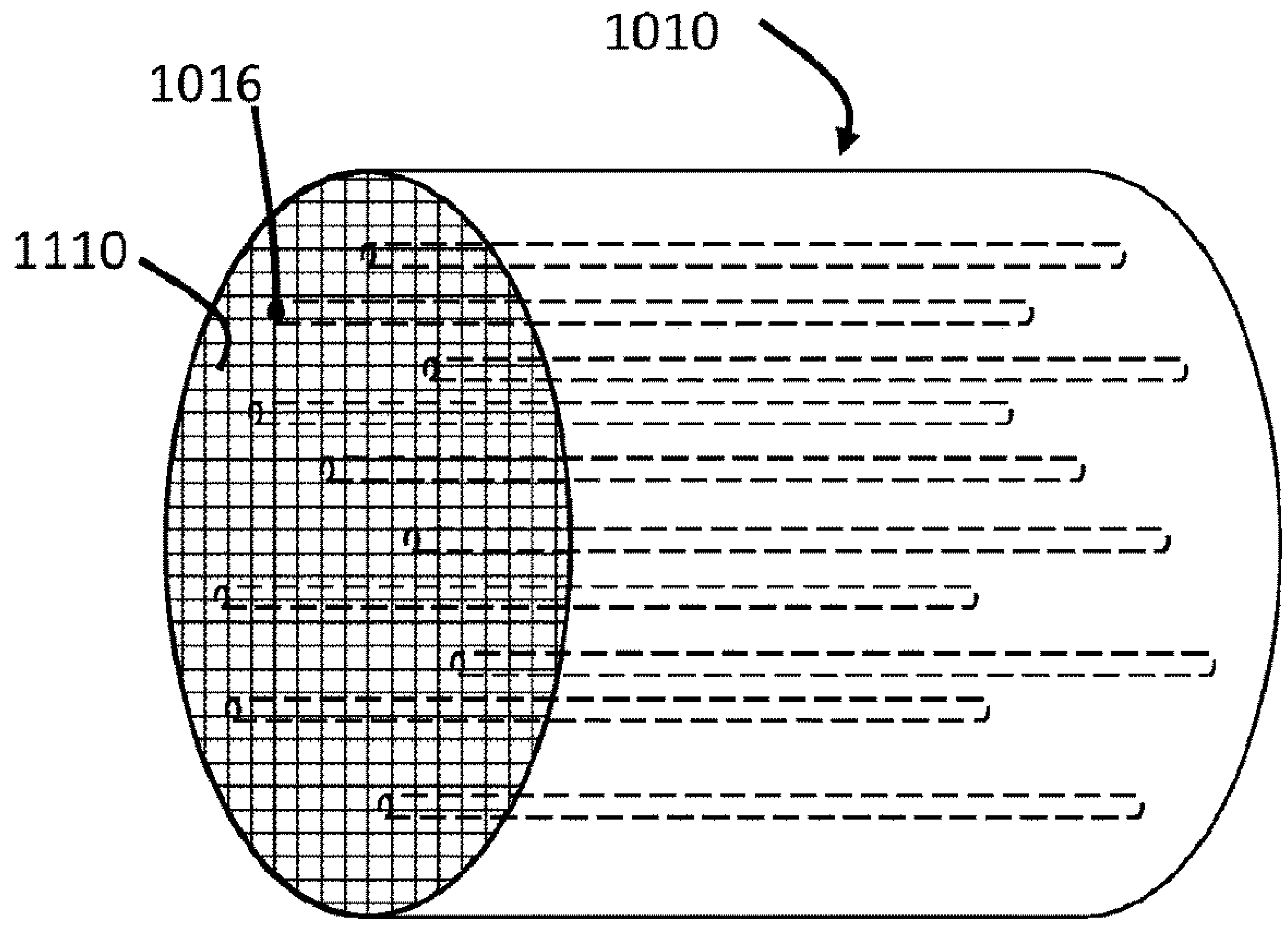


FIG. 11B

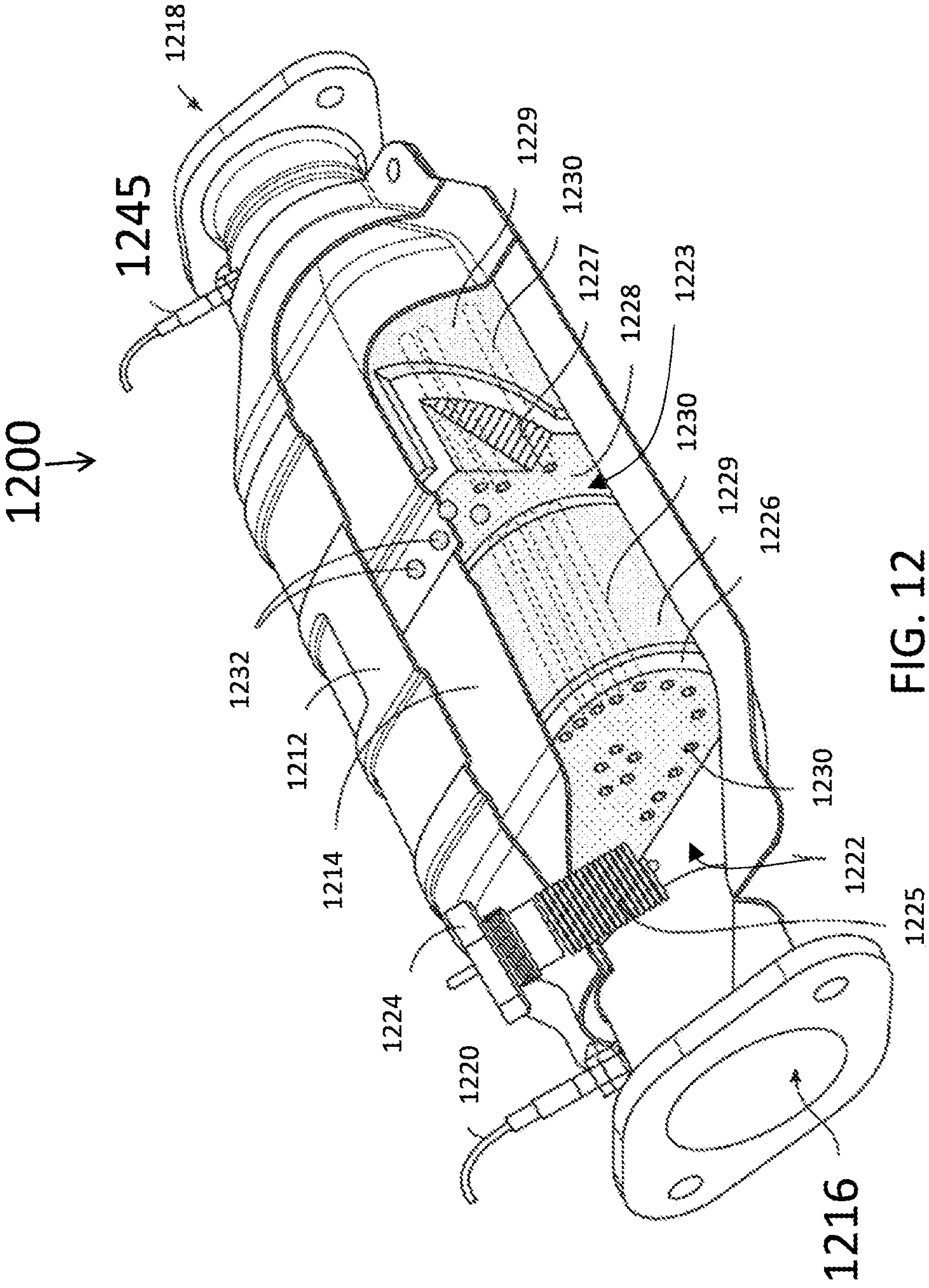

1200
1245
1218
1229
1230
1227
1228
1223
1230
1229
1226
1232
1212
1214
1230
1222
1225
1224
1220
1216

FIG. 12

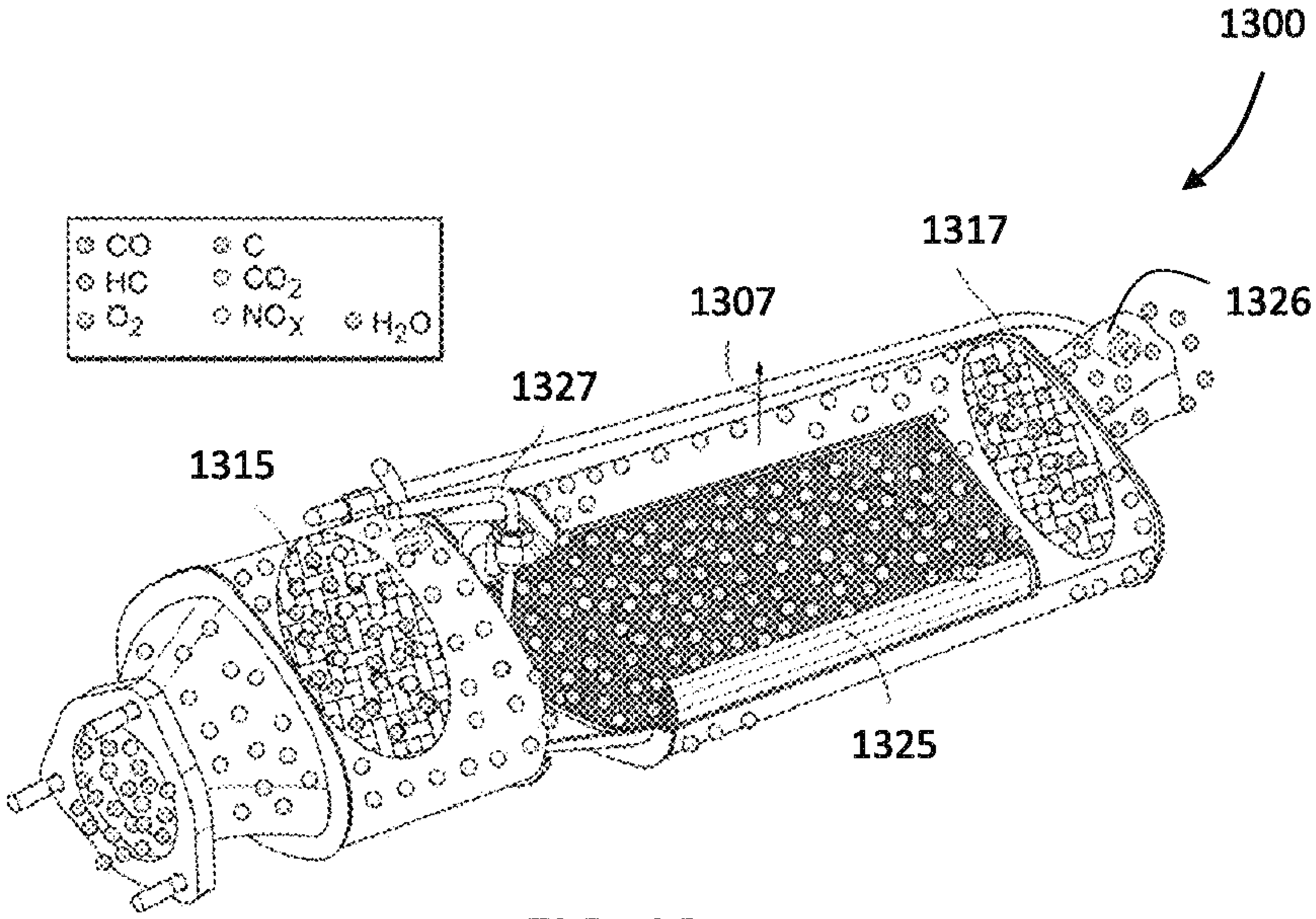


FIG. 13

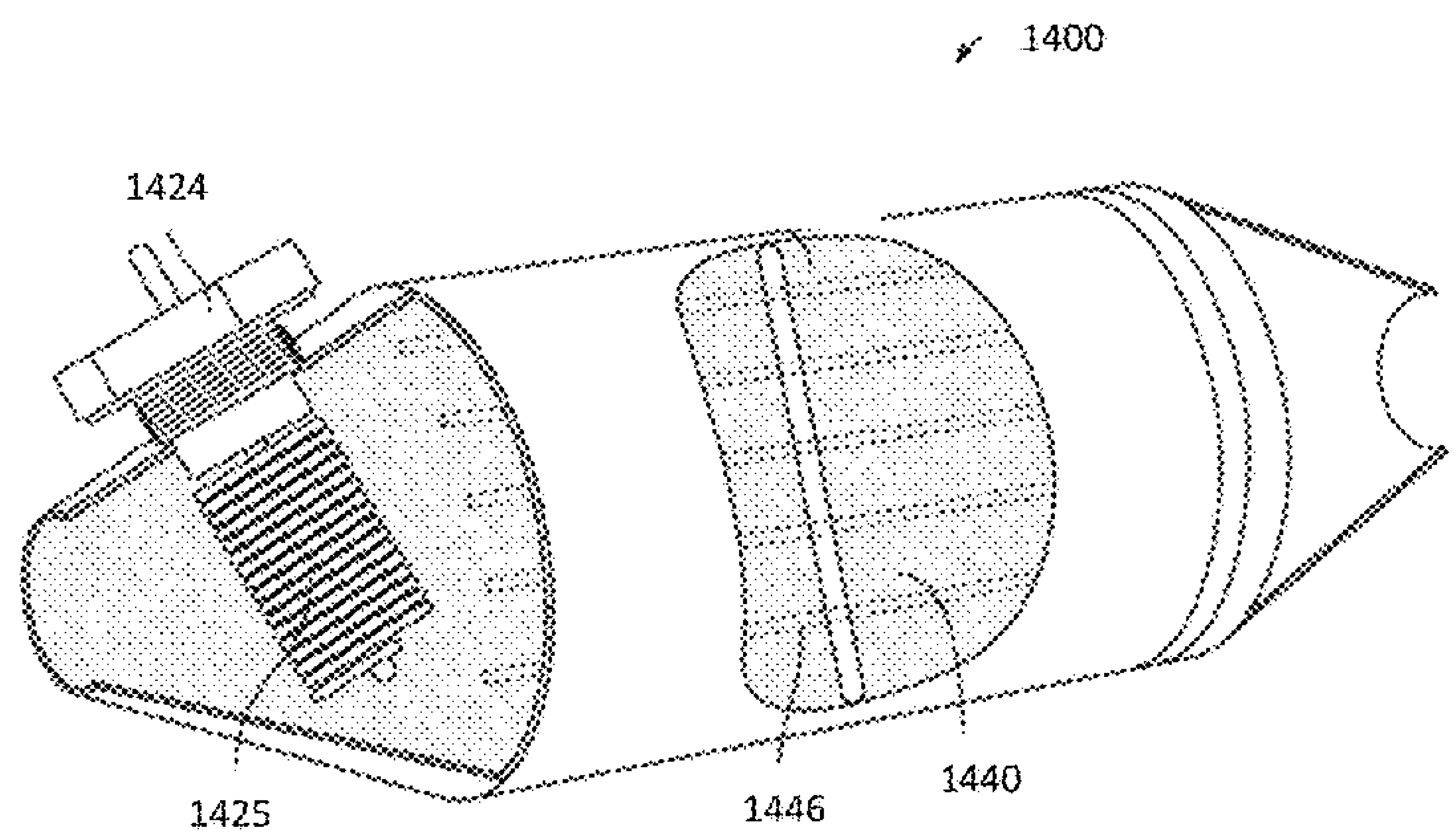


FIG. 14

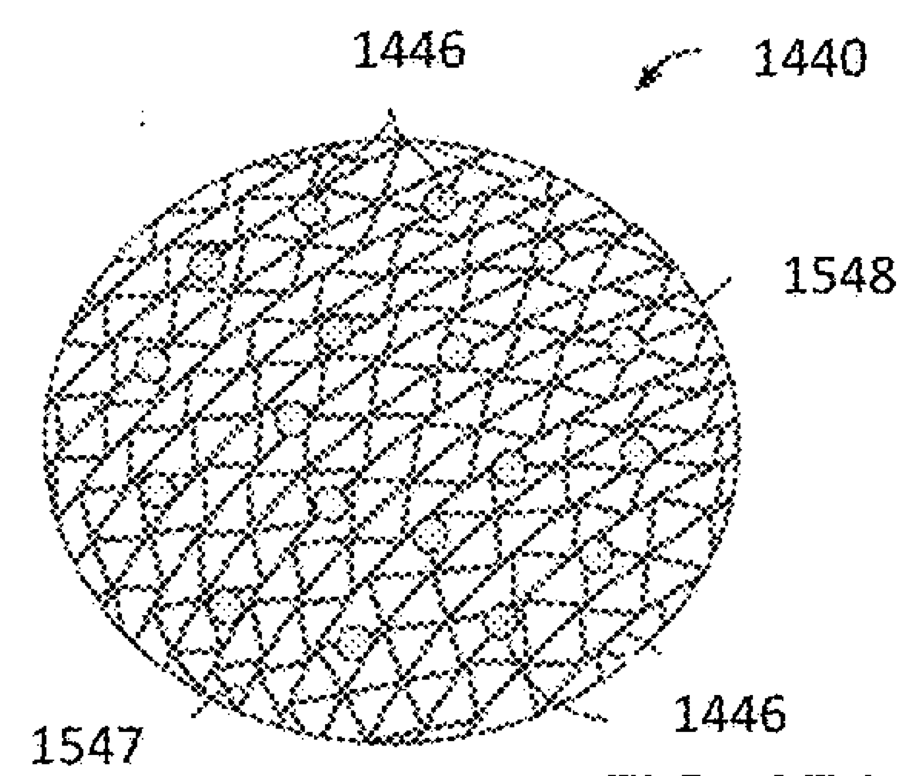


FIG. 15A

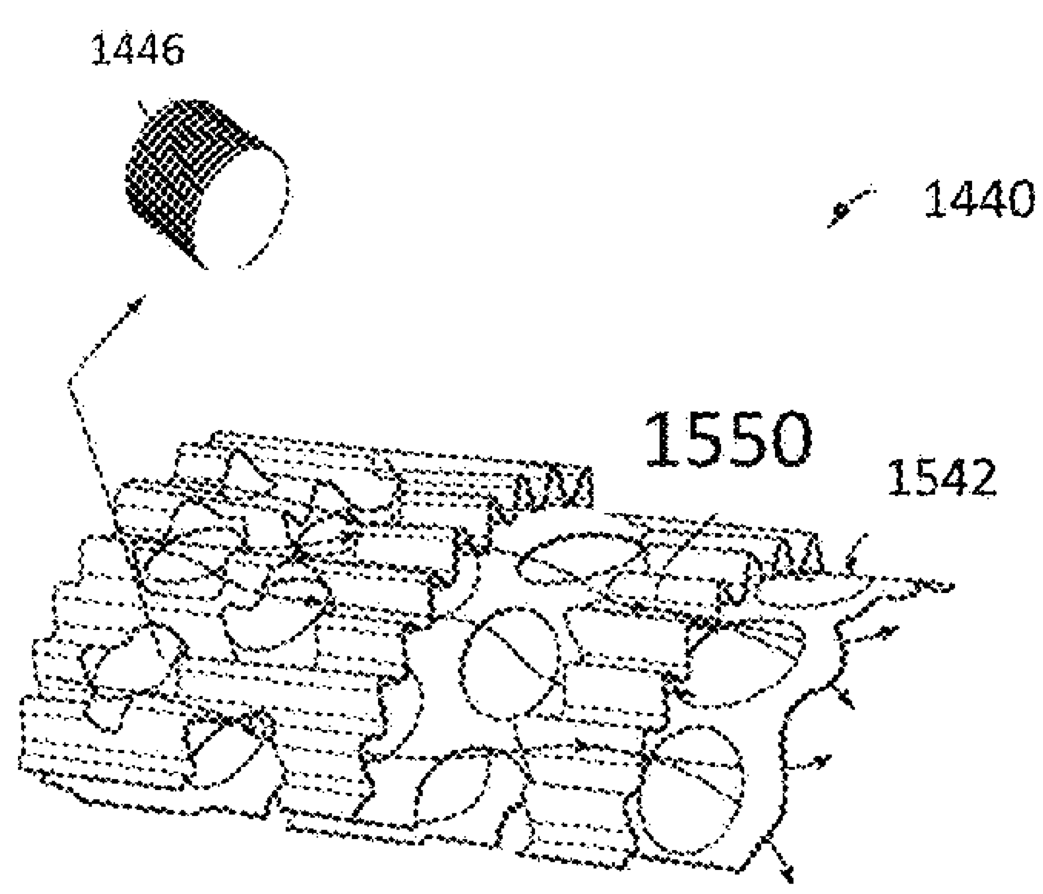
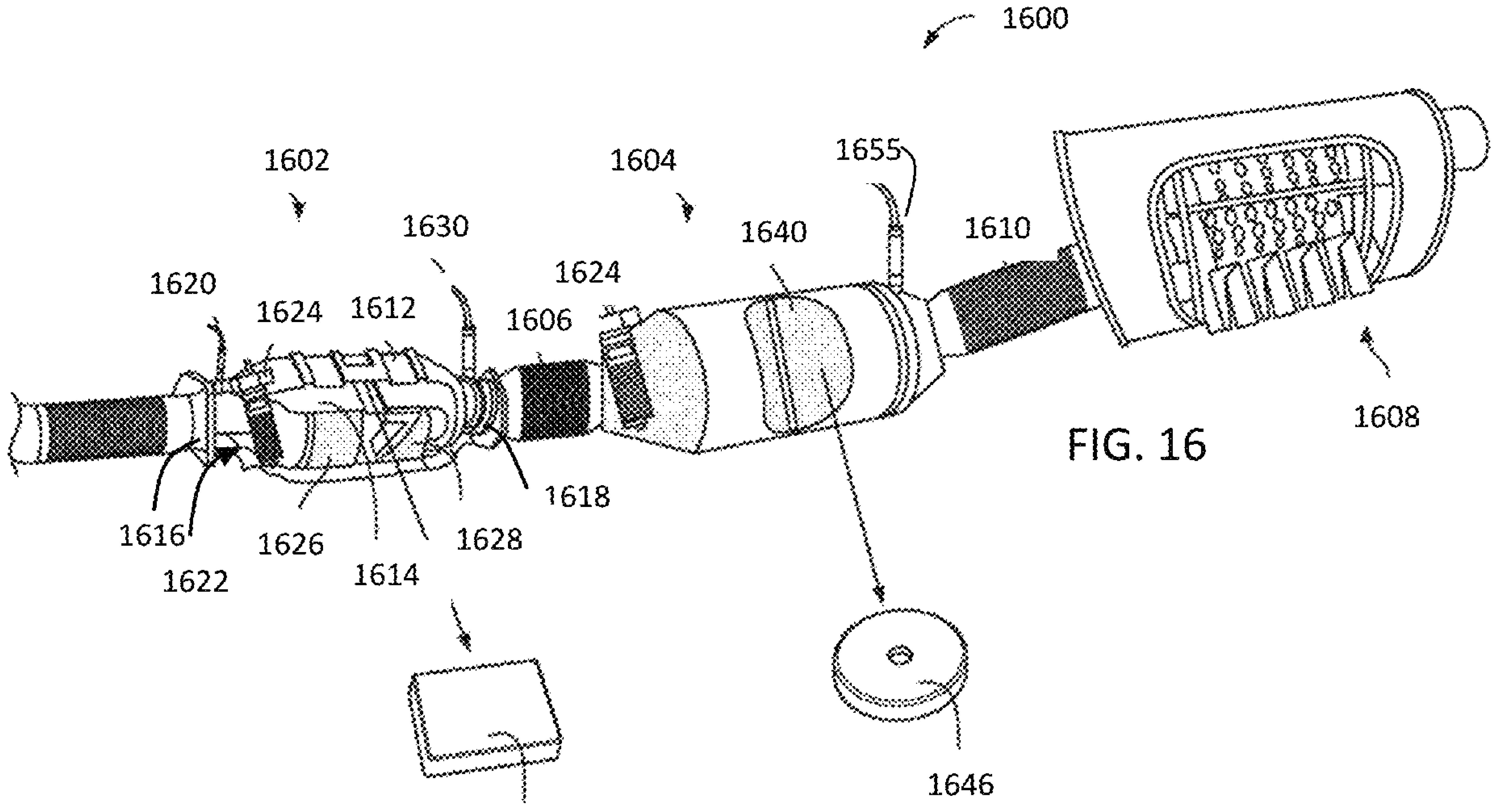


FIG. 15B



1600
1602
1604
1655
1630
1640
1610
1624
1620
1624
1612
1606
1608
1616
1622
1626
1614
1628
1618
1632
1646

FIG. 16

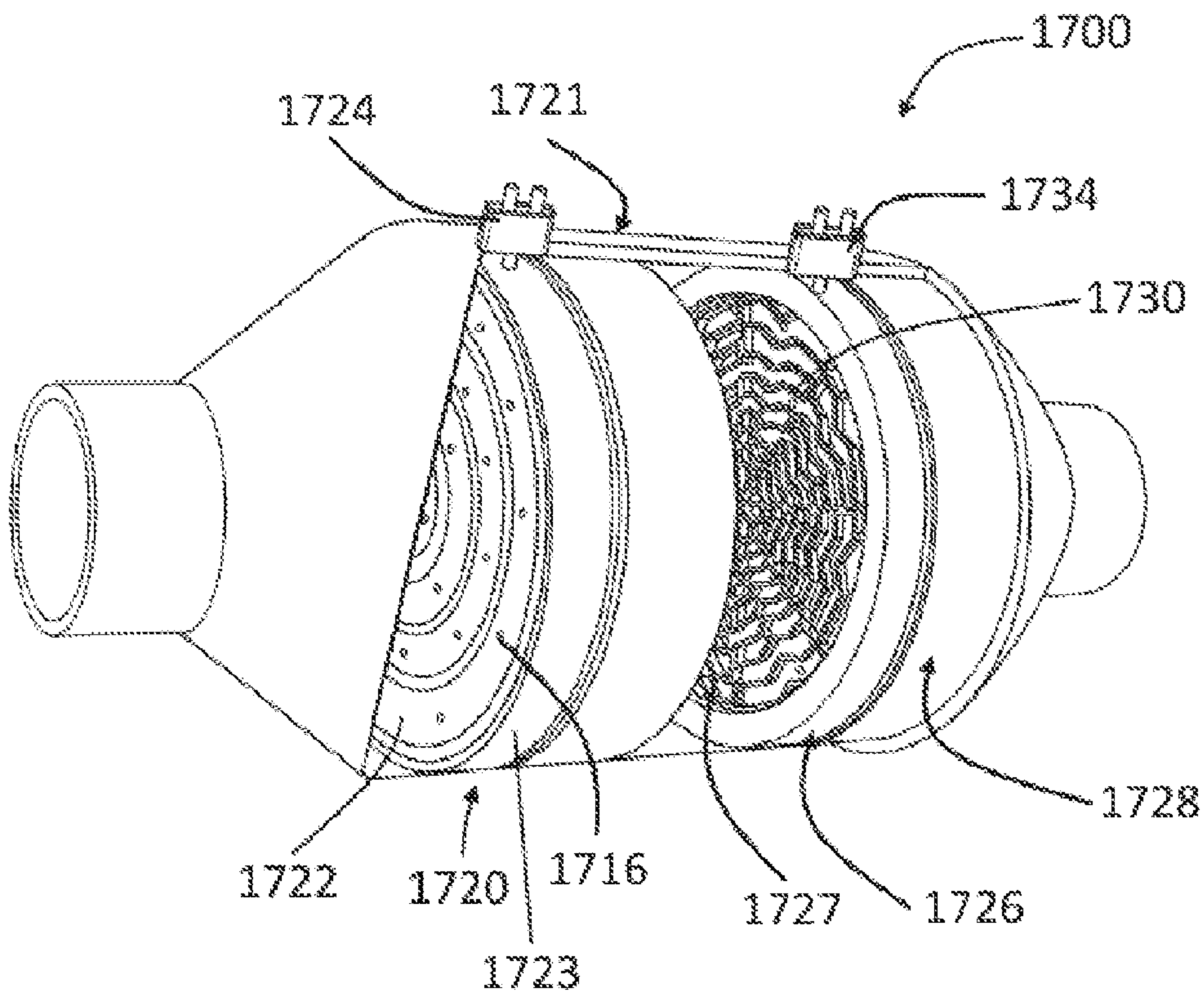


FIG. 17

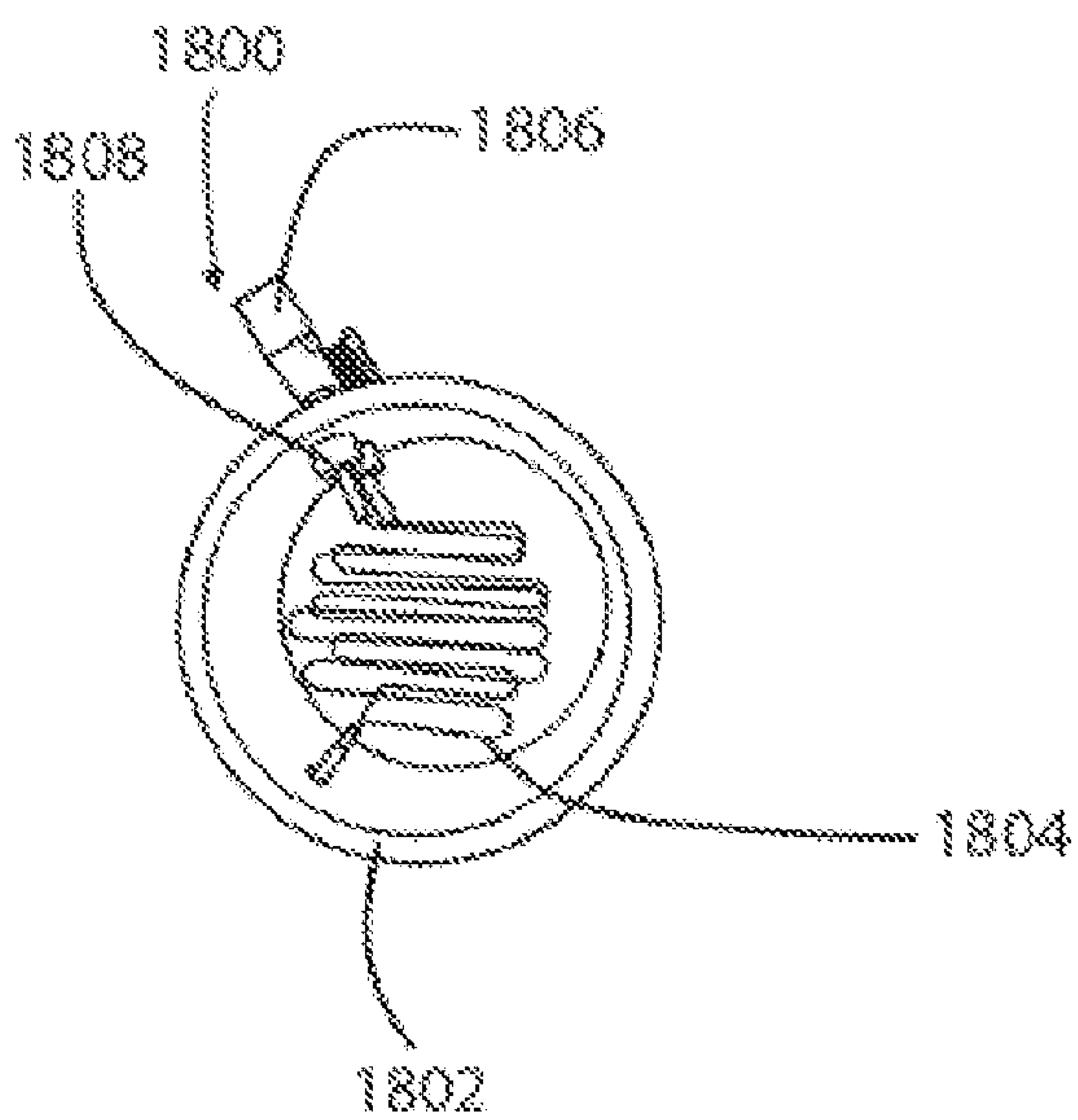


FIG. 18A

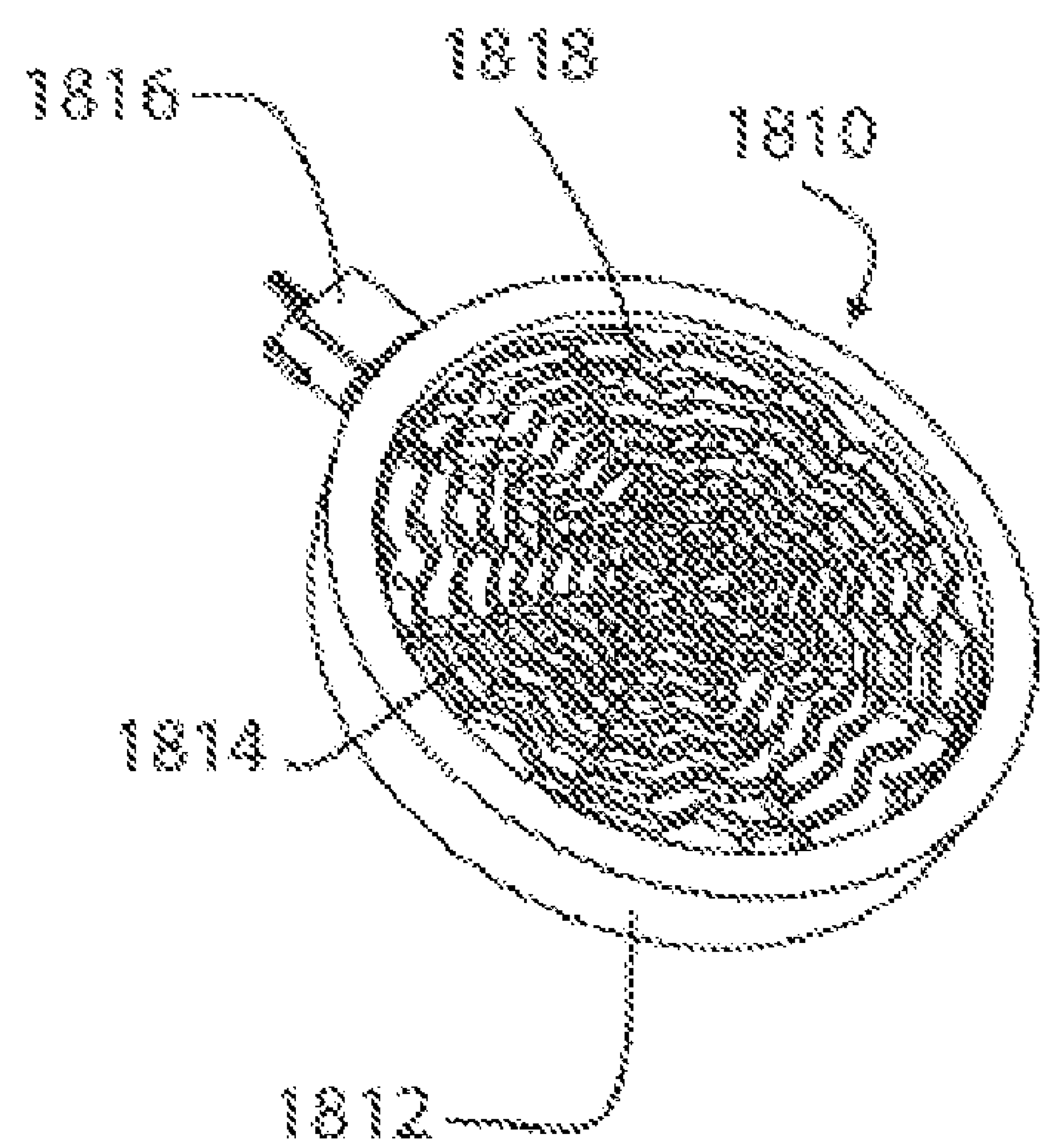


FIG. 18B

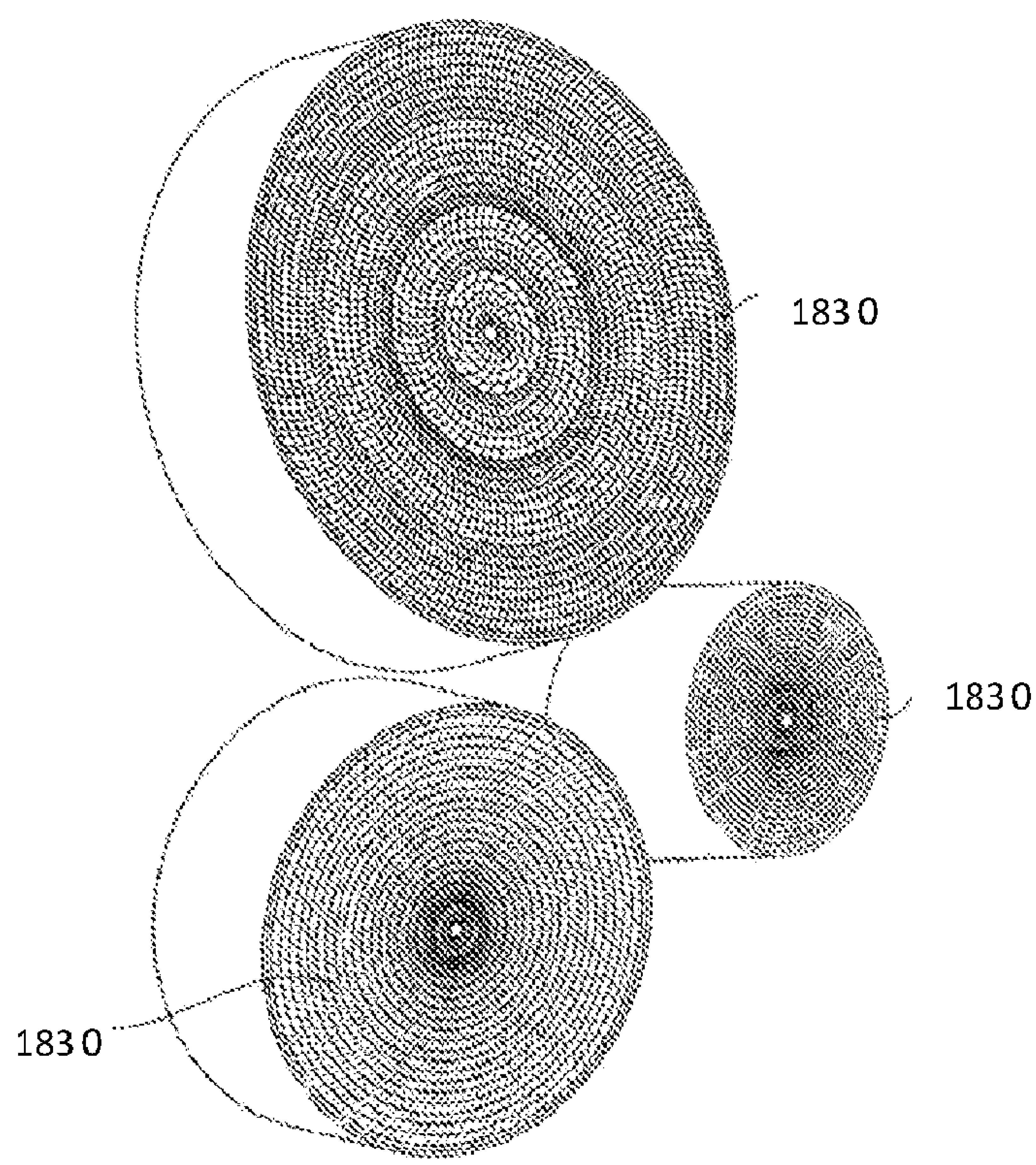


FIG. 18C

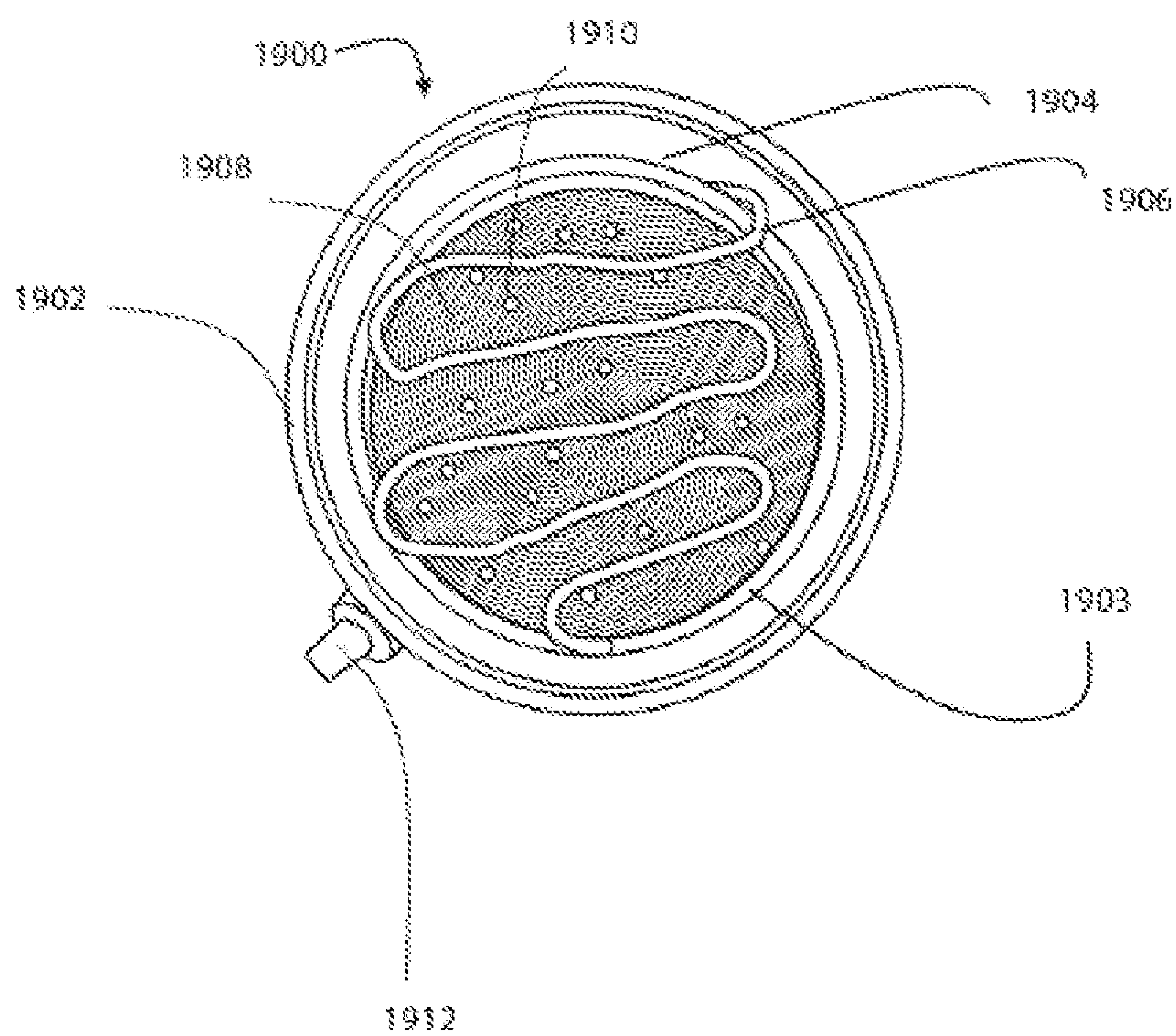


FIG. 19

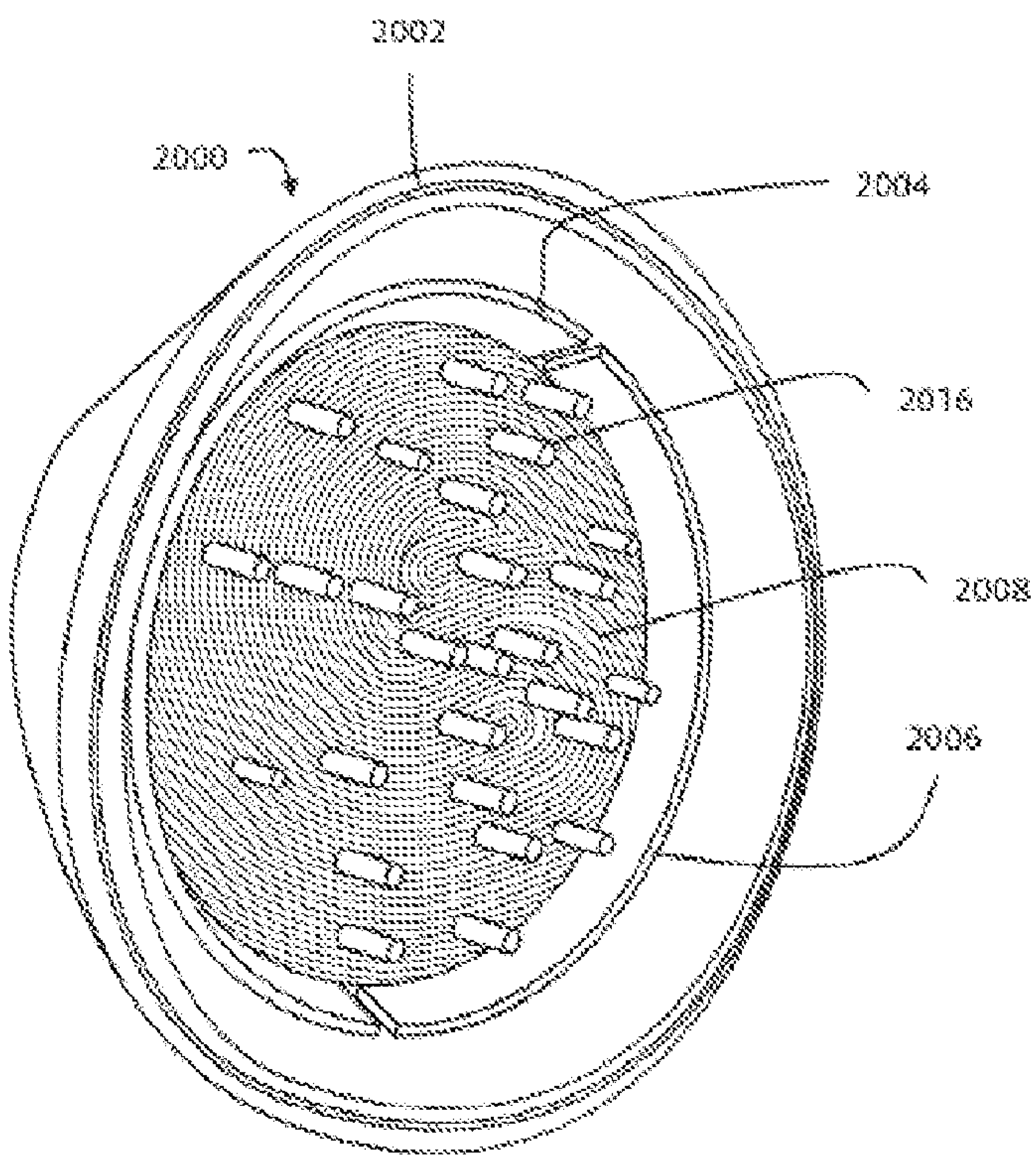


FIG. 20

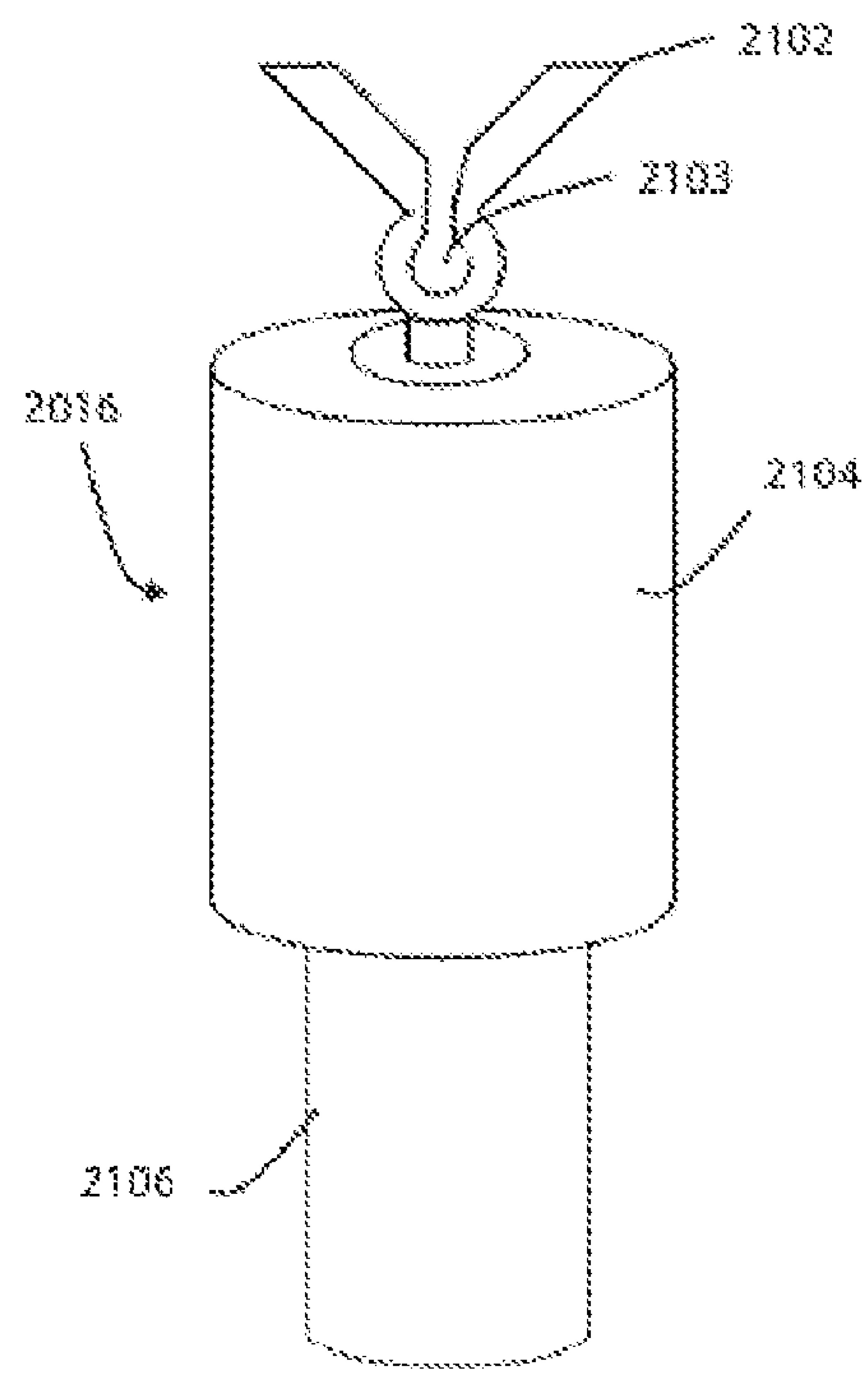


FIG. 21

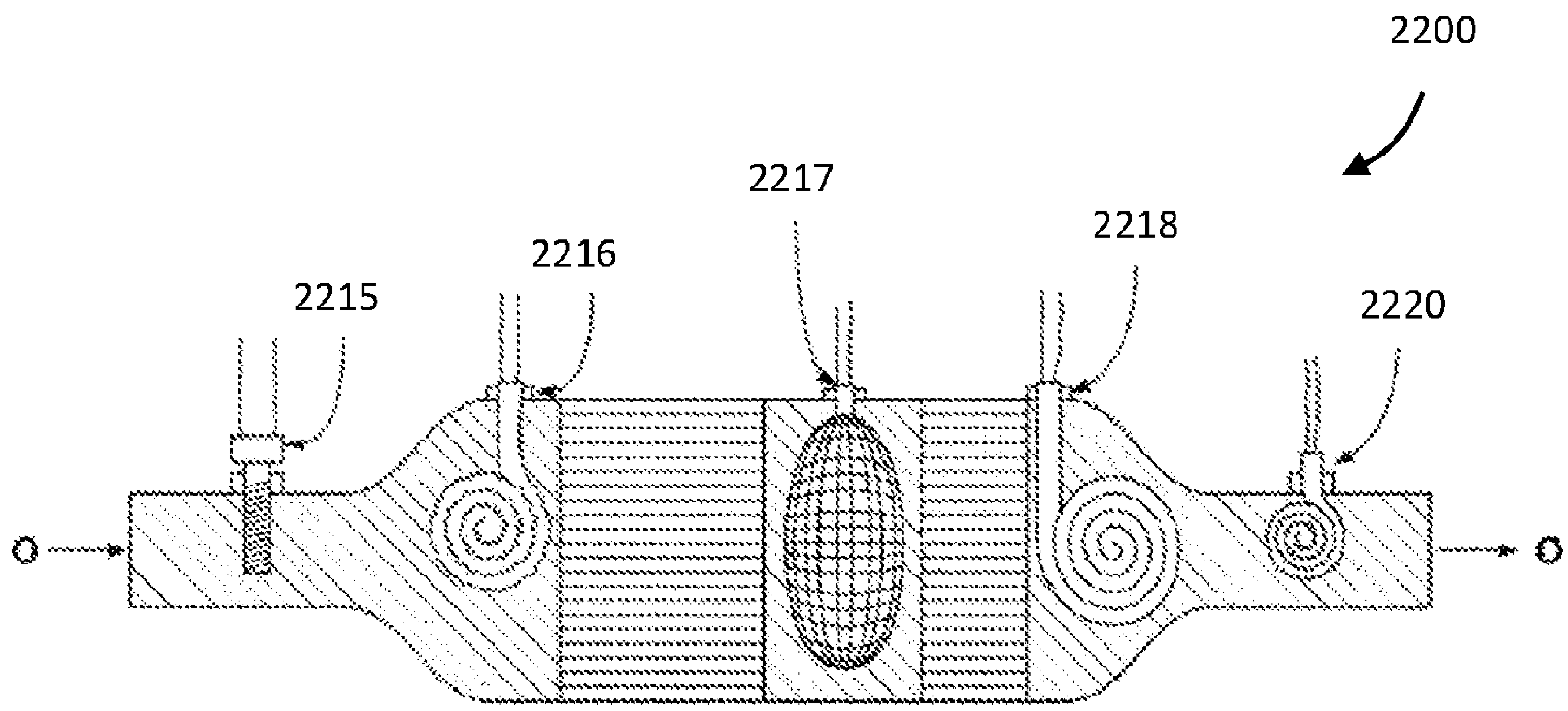


FIG. 22

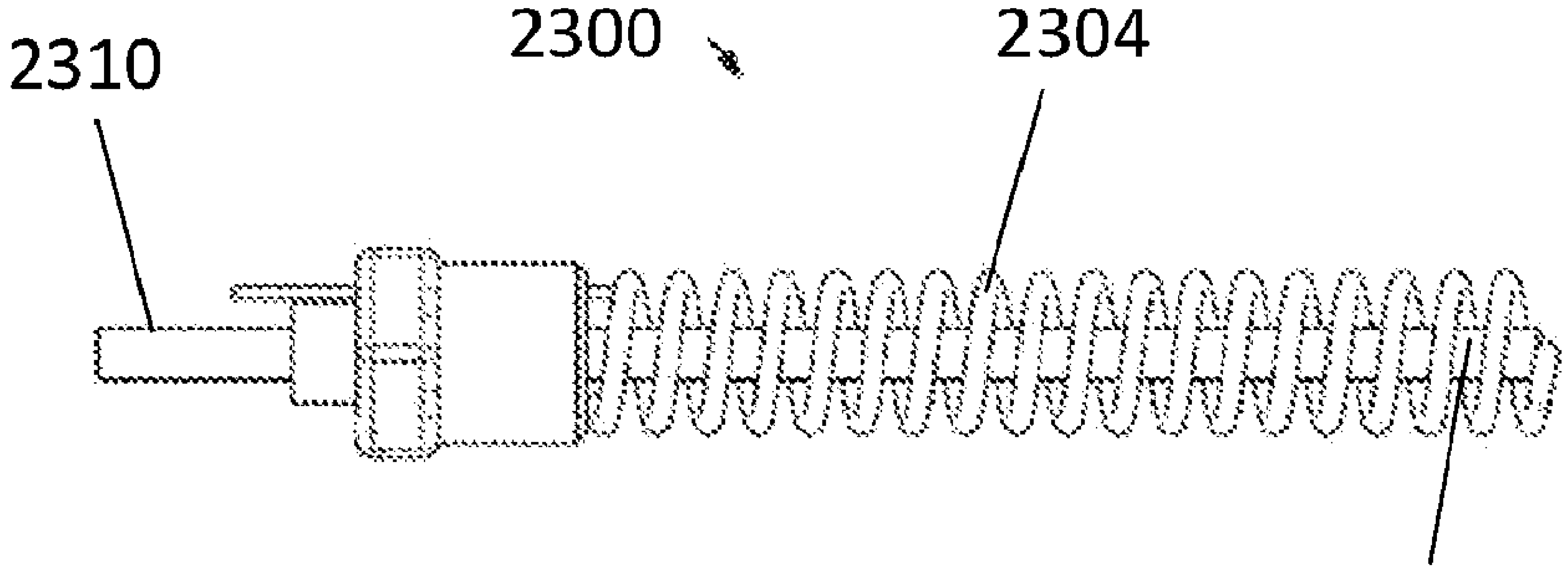


FIG. 23

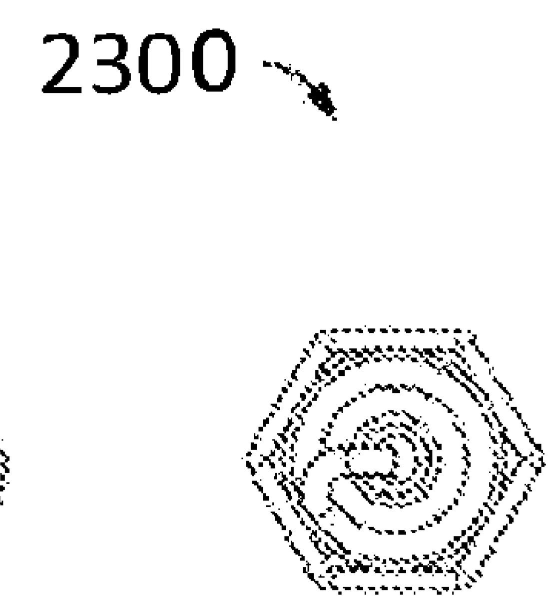


FIG. 24

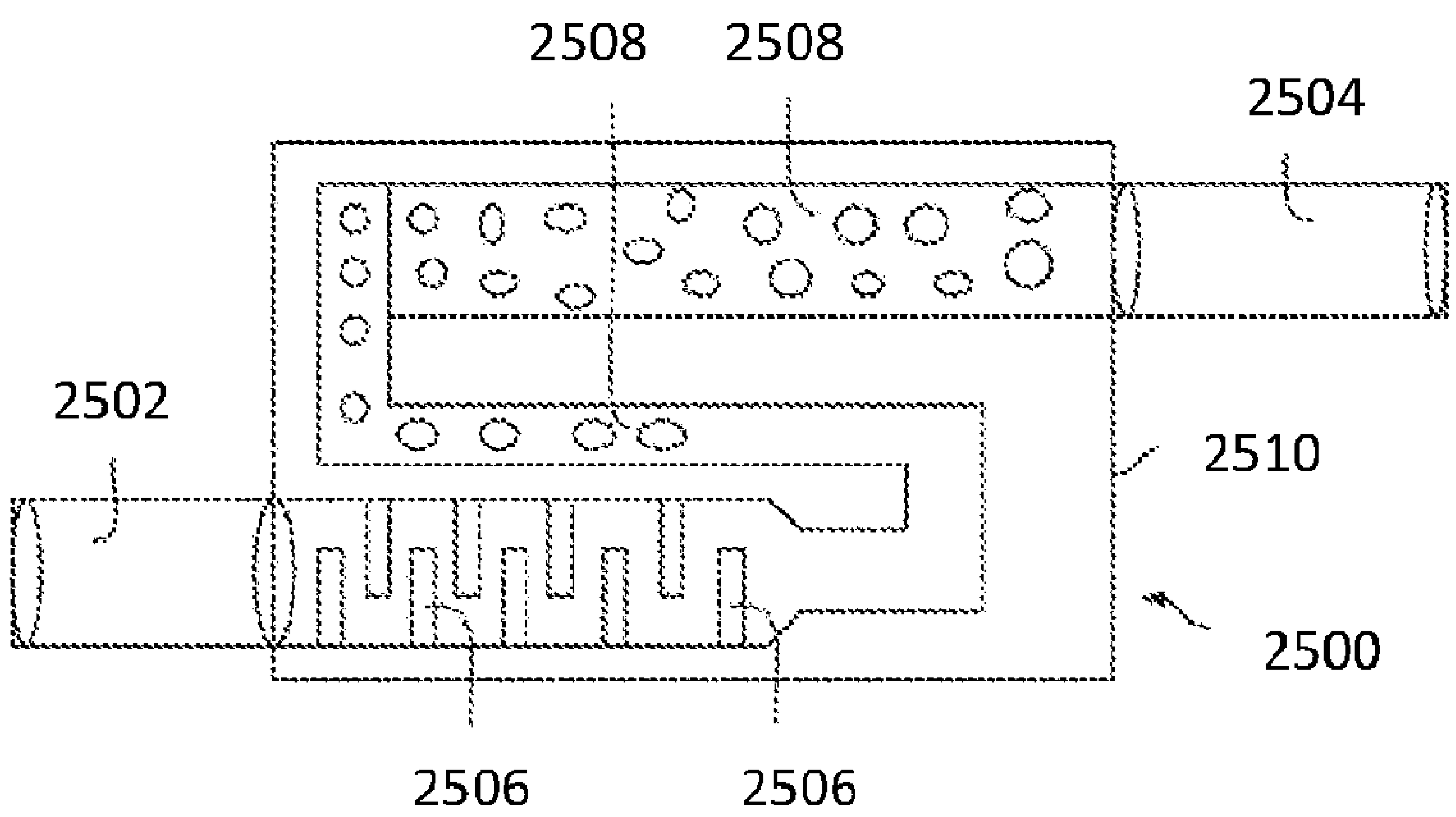

2508
2508
2504
2502
2510
2500
2506
2506

FIG. 25

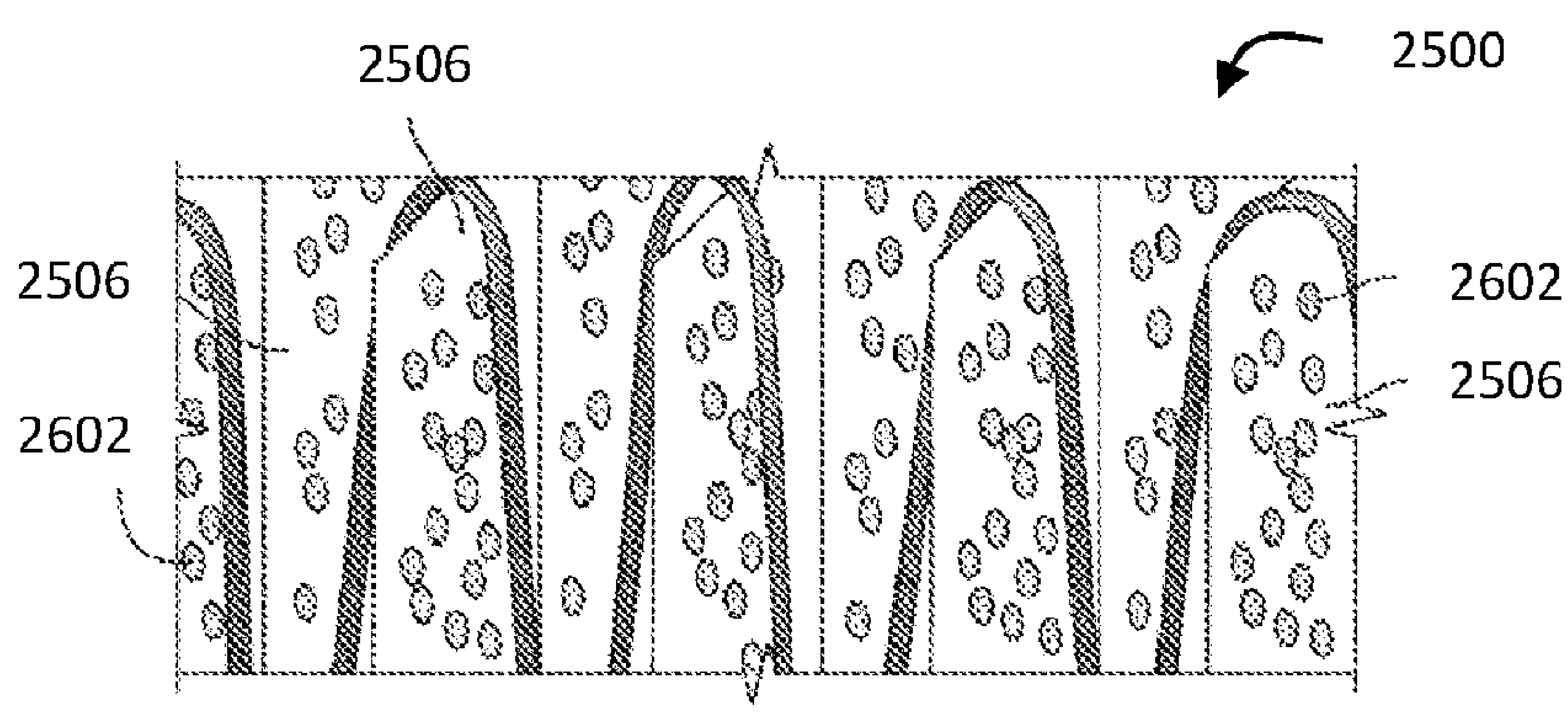

2506
2500
2506
2602
2602
2506

FIG. 26

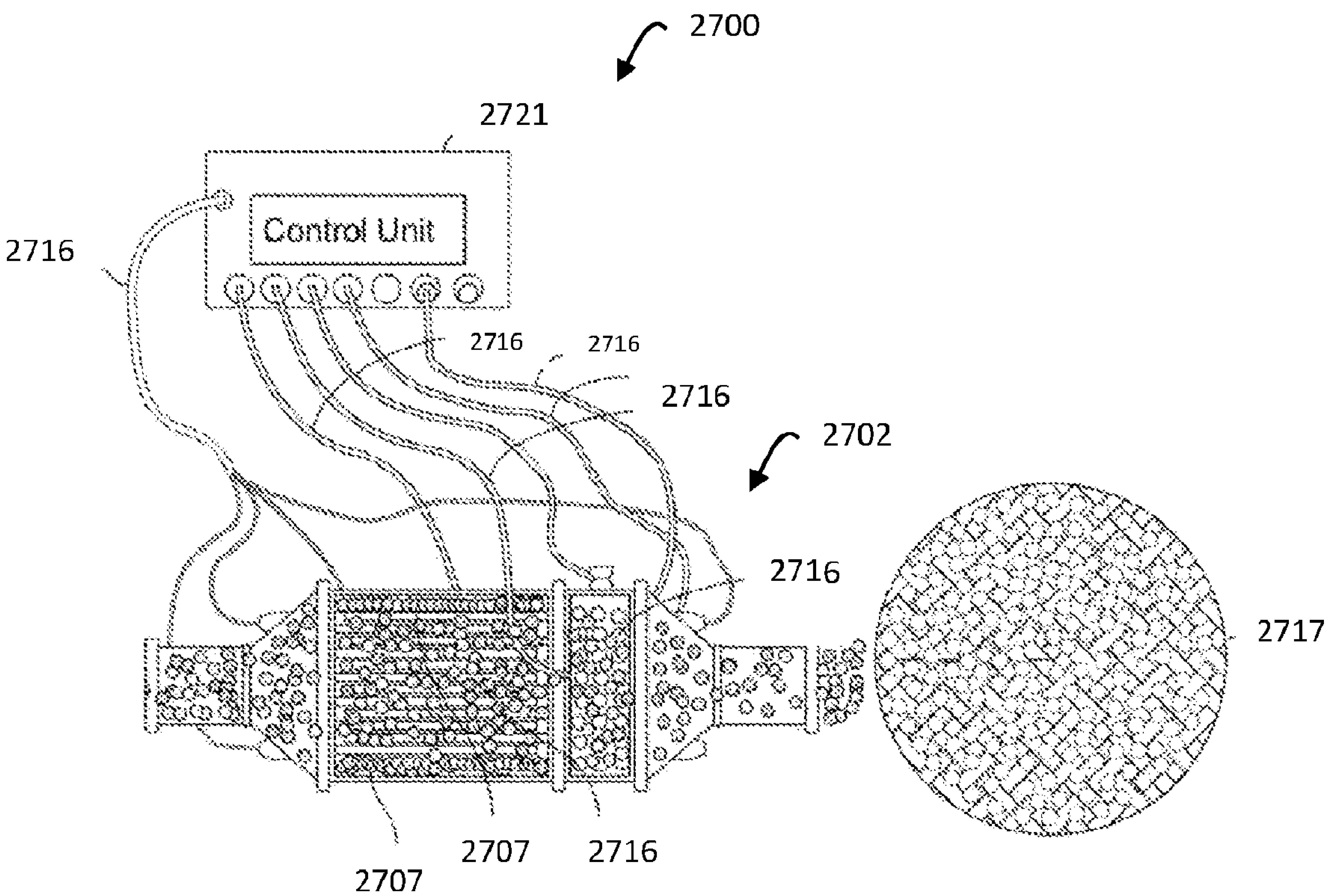
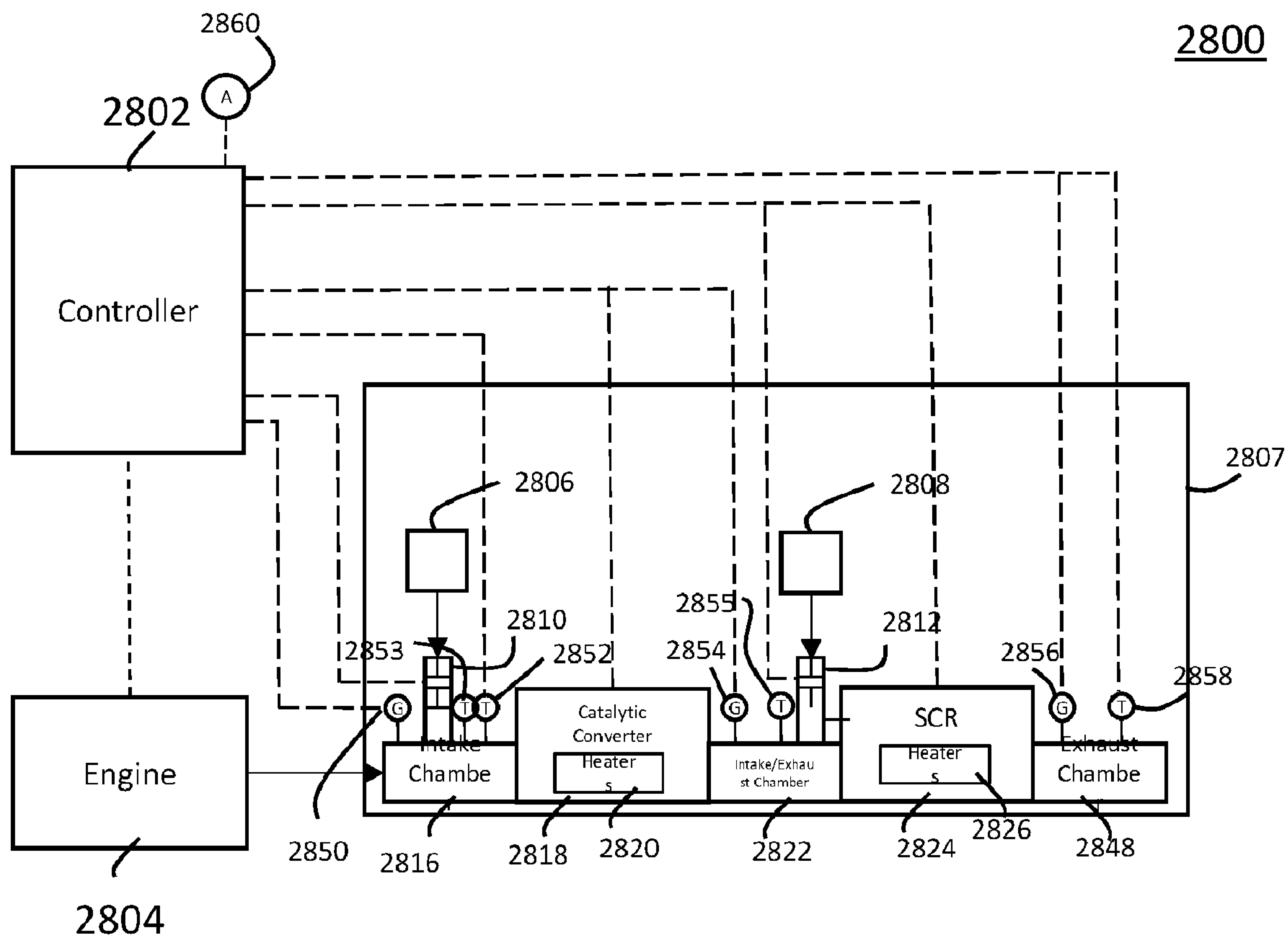

2700
2721
Control Unit
2716
2716
2716
2716
2702
2716
2717
2707
2707
2716

FIG. 27



2800
2860
A
2802
Controller
2804
Engine
2807
2806
2808
2810
2812
2853
2852
2855
2854
2856
2858
G
T
Catalytic Converter
Heaters
SCR
Heaters
Intake Chambe
Intake/Exhaust Chamber
Exhaust Chambe
2850
2816
2818
2820
2822
2824
2826
2848

FIG. 28

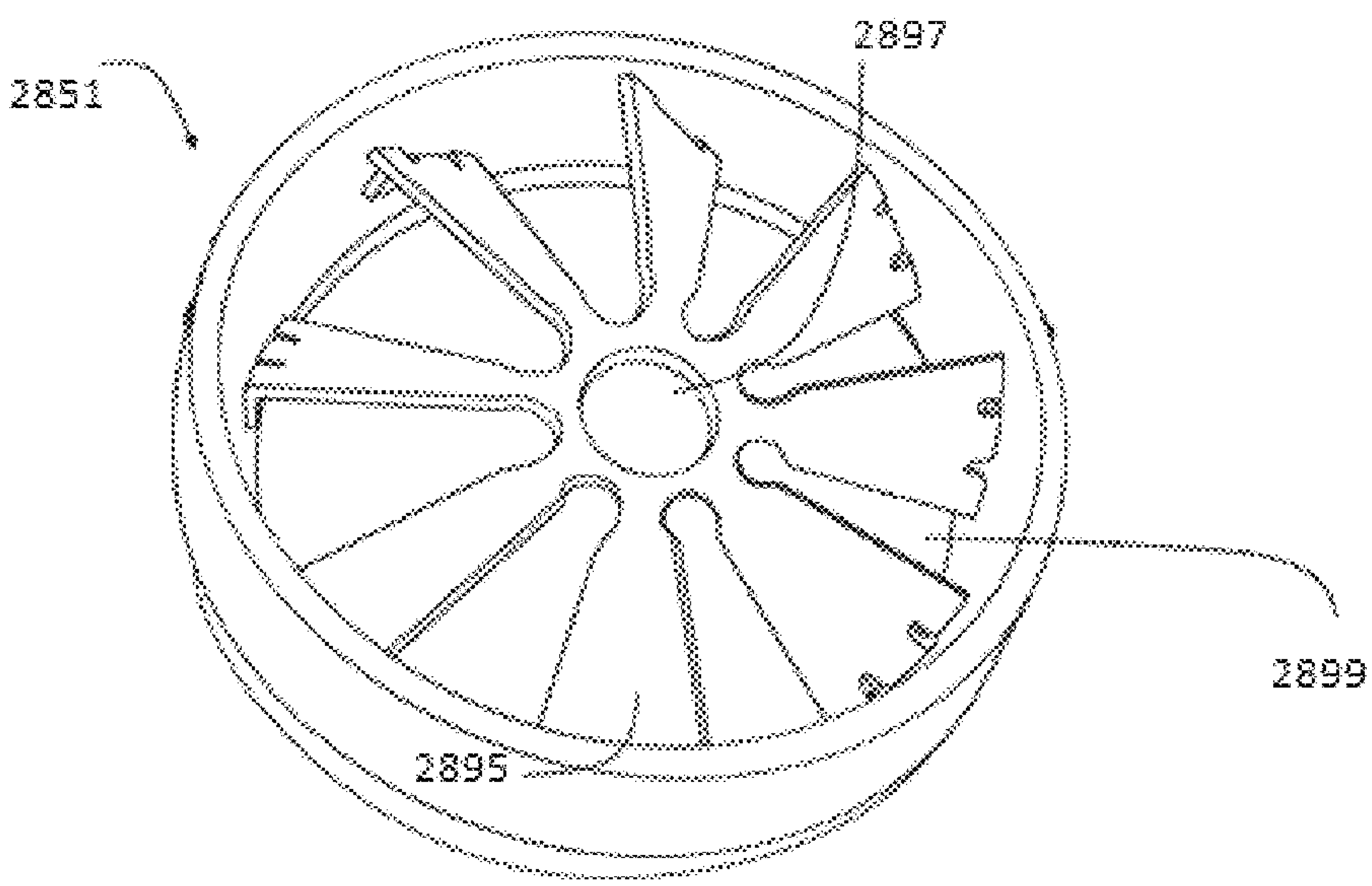
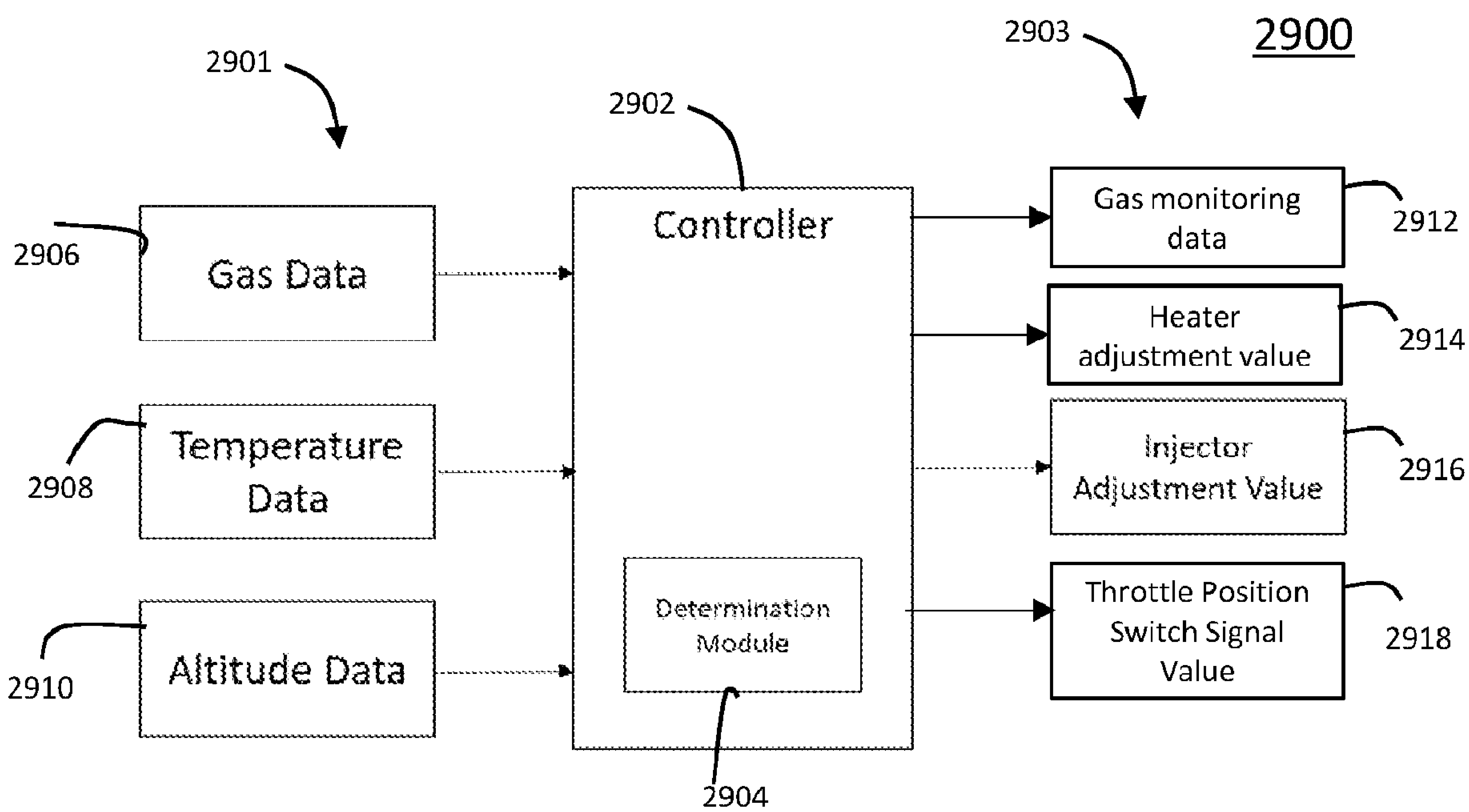


FIG. 28A



2900
2901
2902
2903
Controller
Gas Data
Temperature Data
Altitude Data
Determination Module
Gas monitoring data
Heater adjustment value
Injector Adjustment Value
Throttle Position Switch Signal Value
2904
2906
2908
2910
2912
2914
2916
2918

FIG. 29

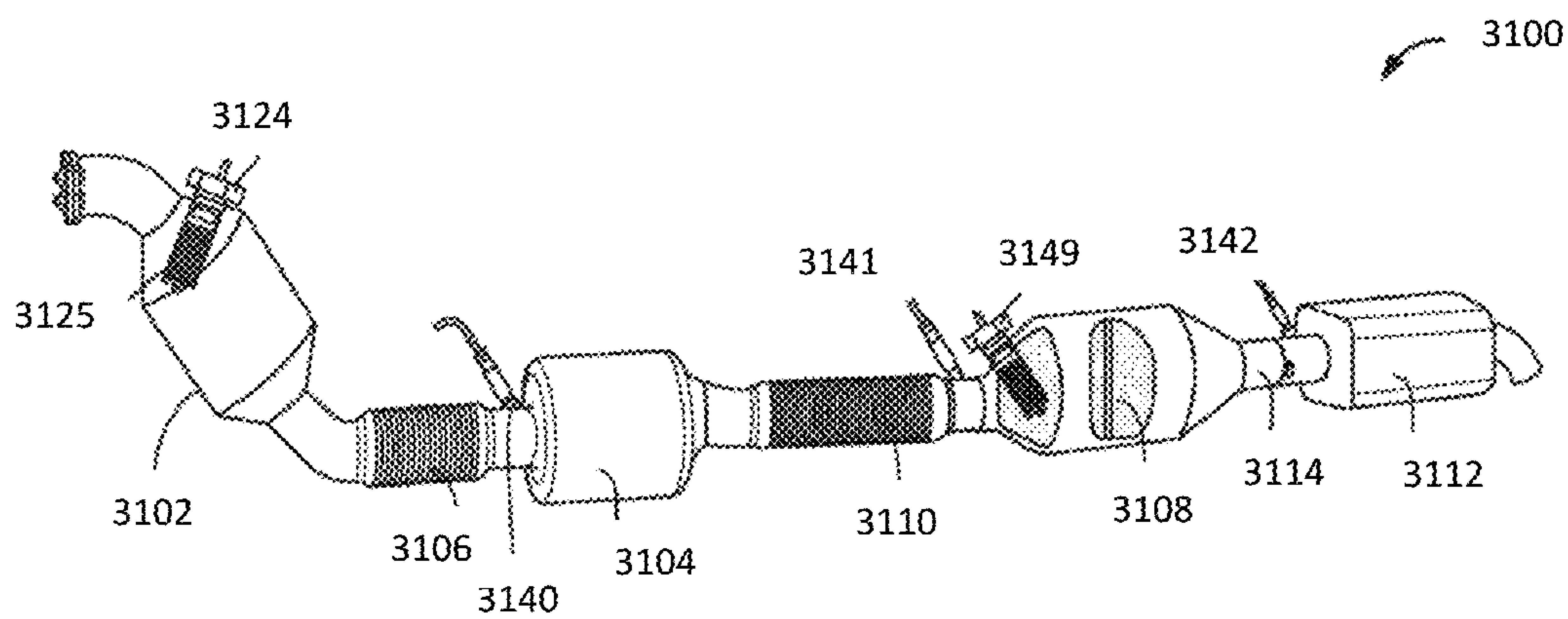


FIG. 30A

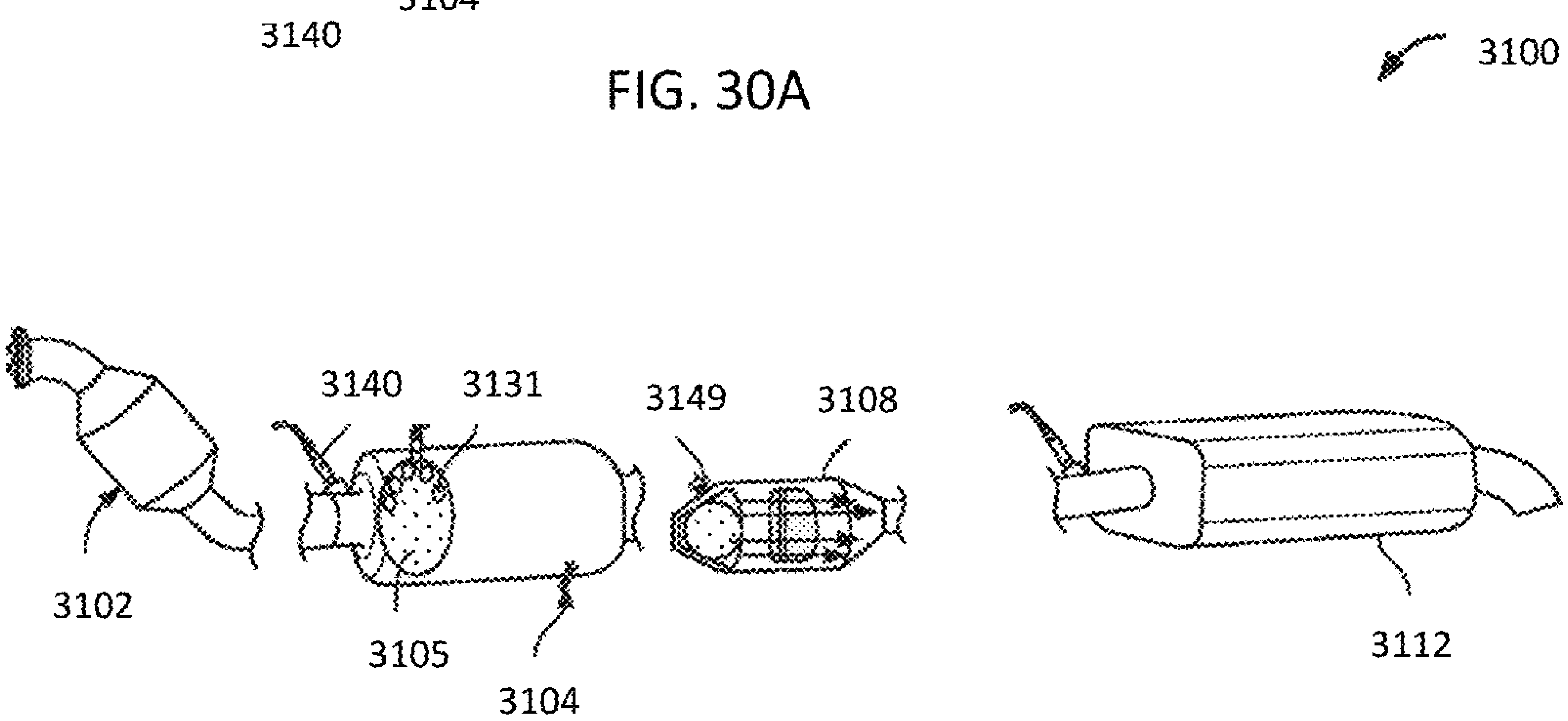


FIG. 30B

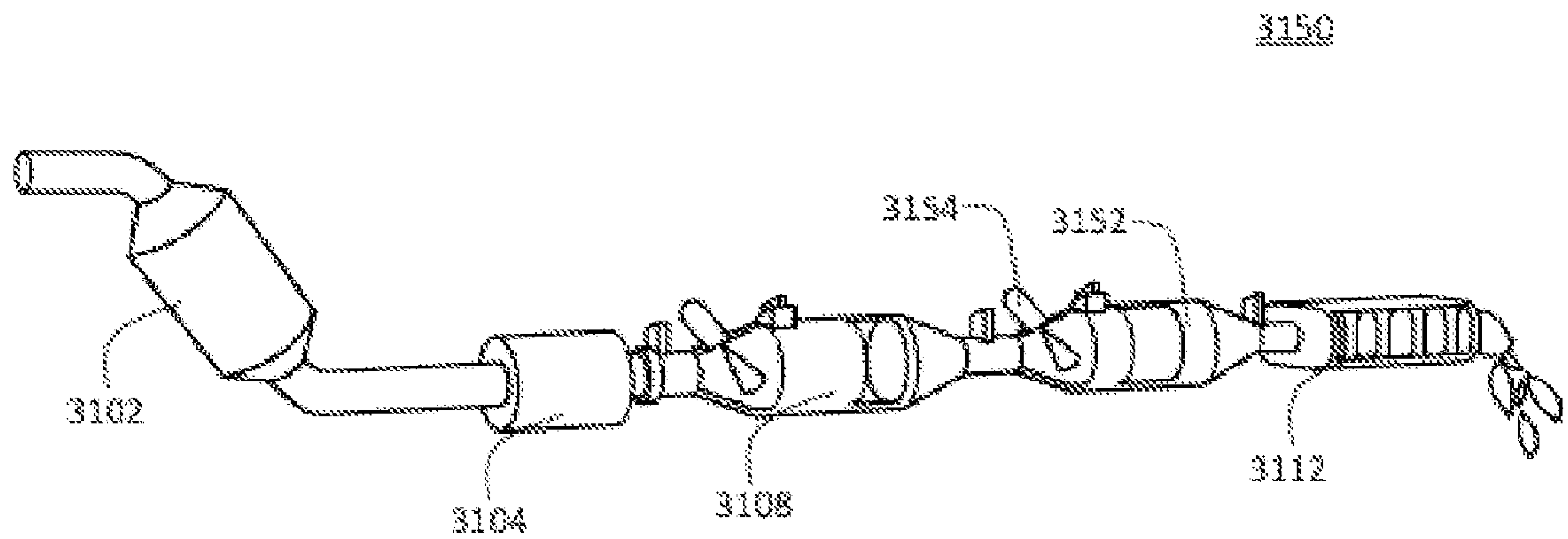


FIG. 30C

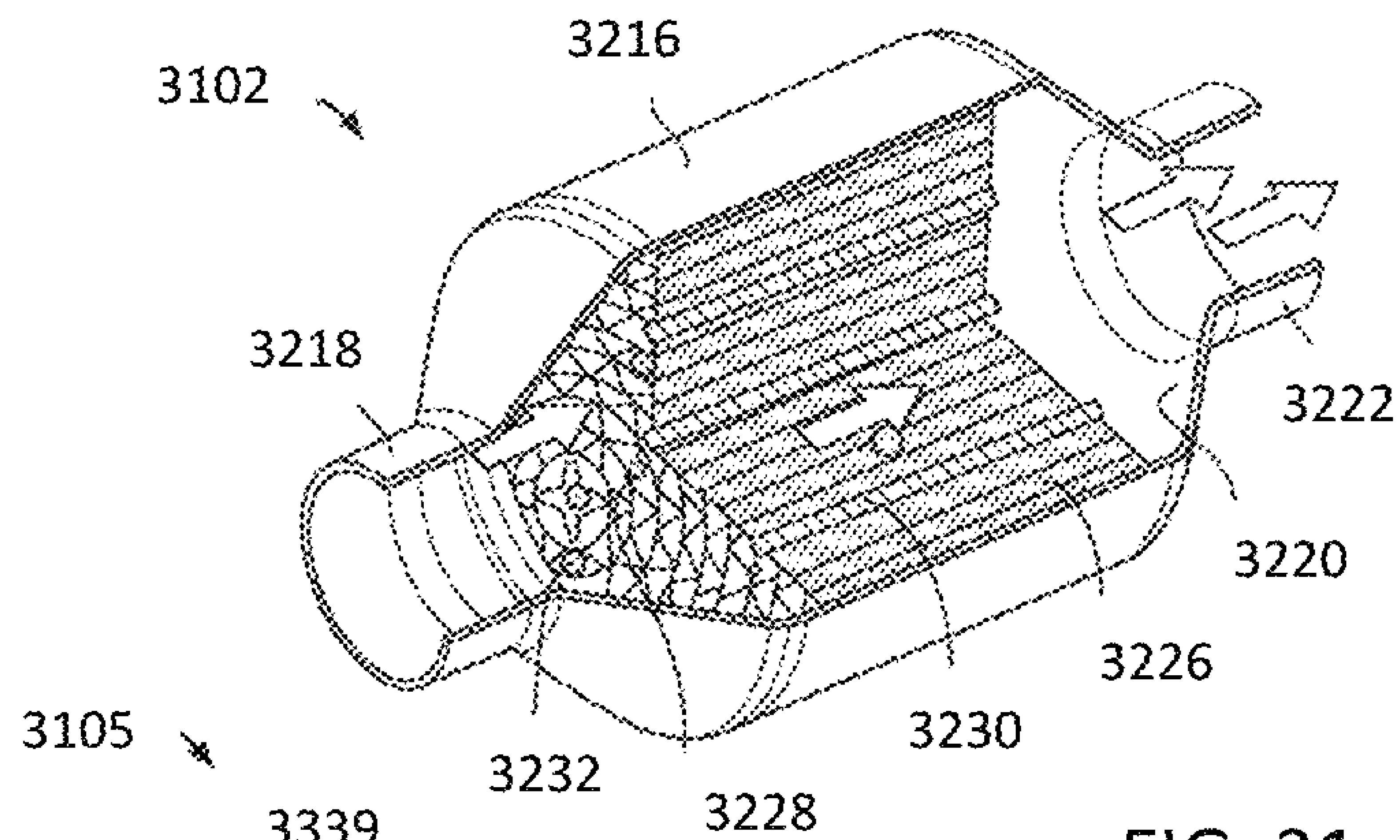


FIG. 31

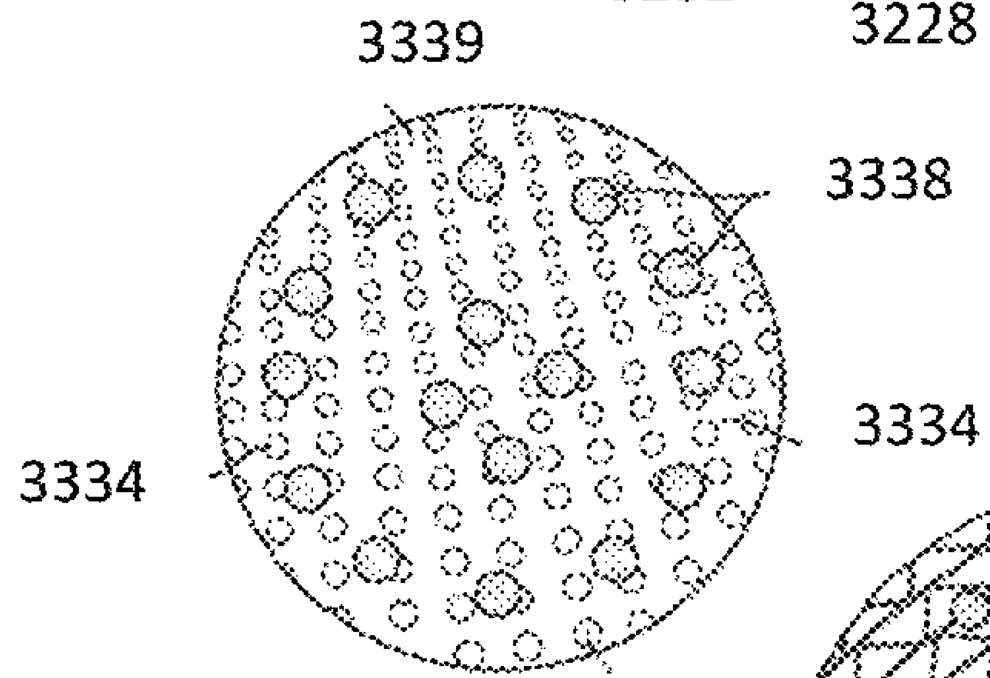


FIG. 32

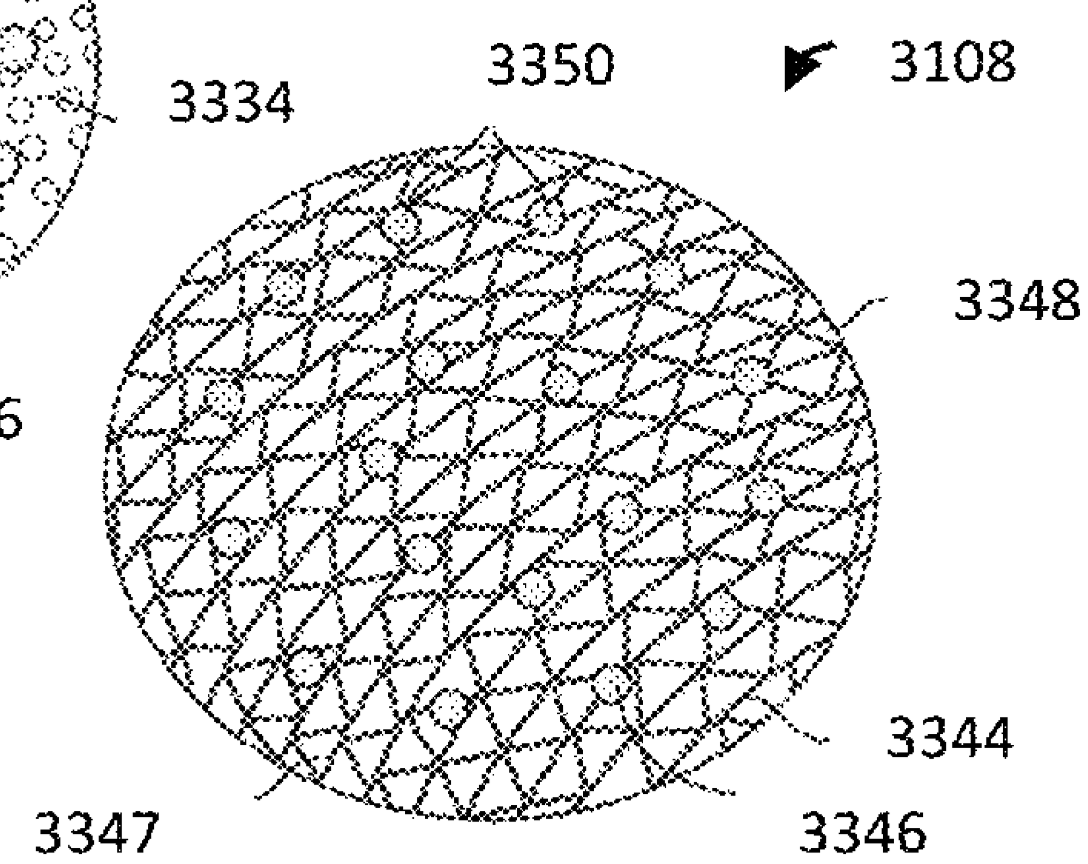


FIG. 33

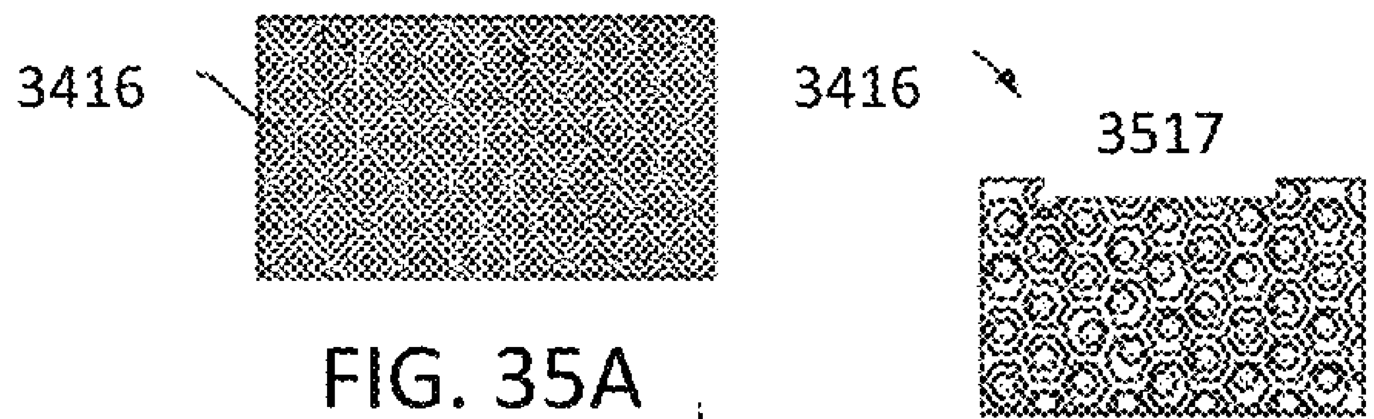


FIG. 35A

FIG. 35B

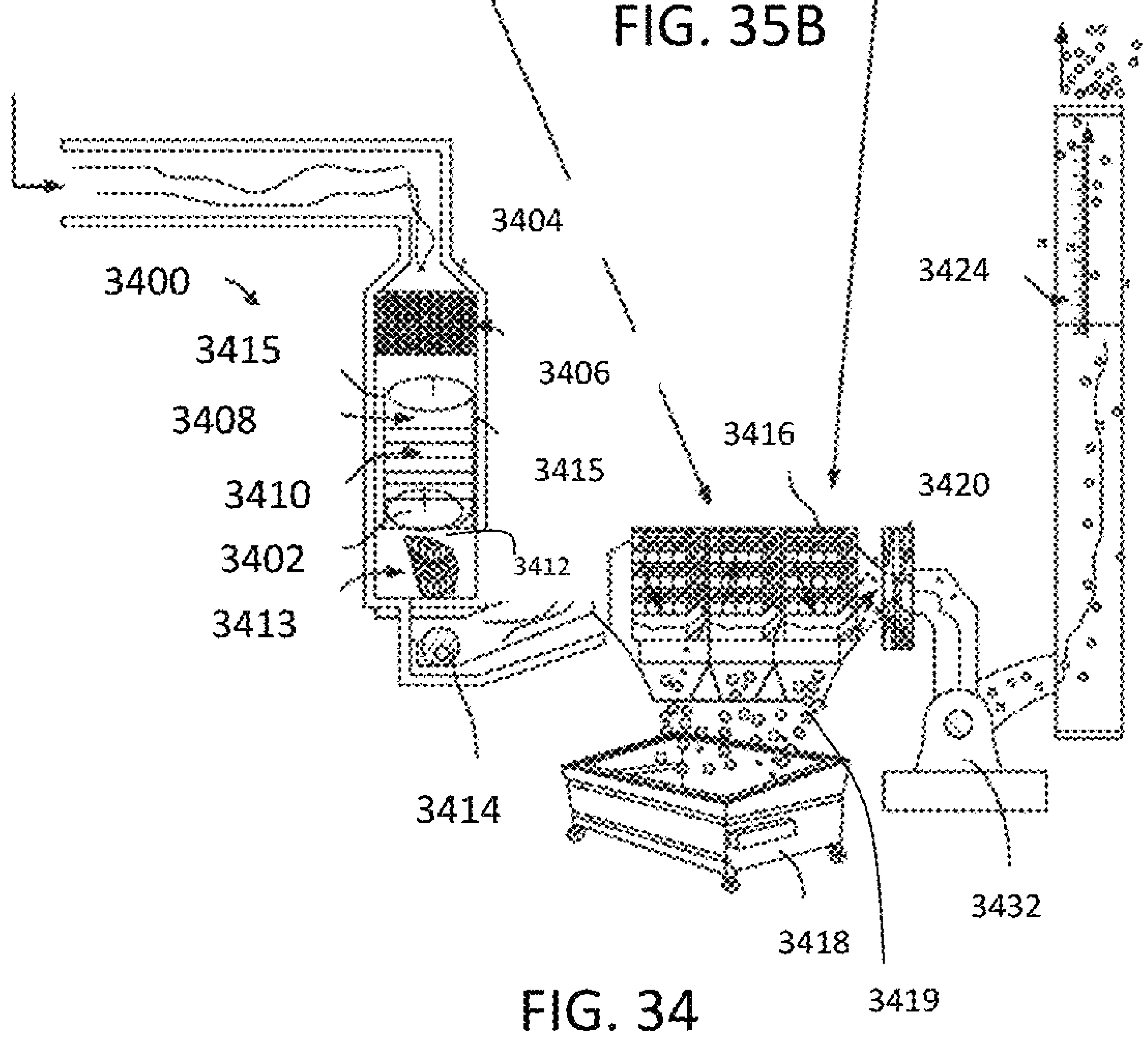


FIG. 34

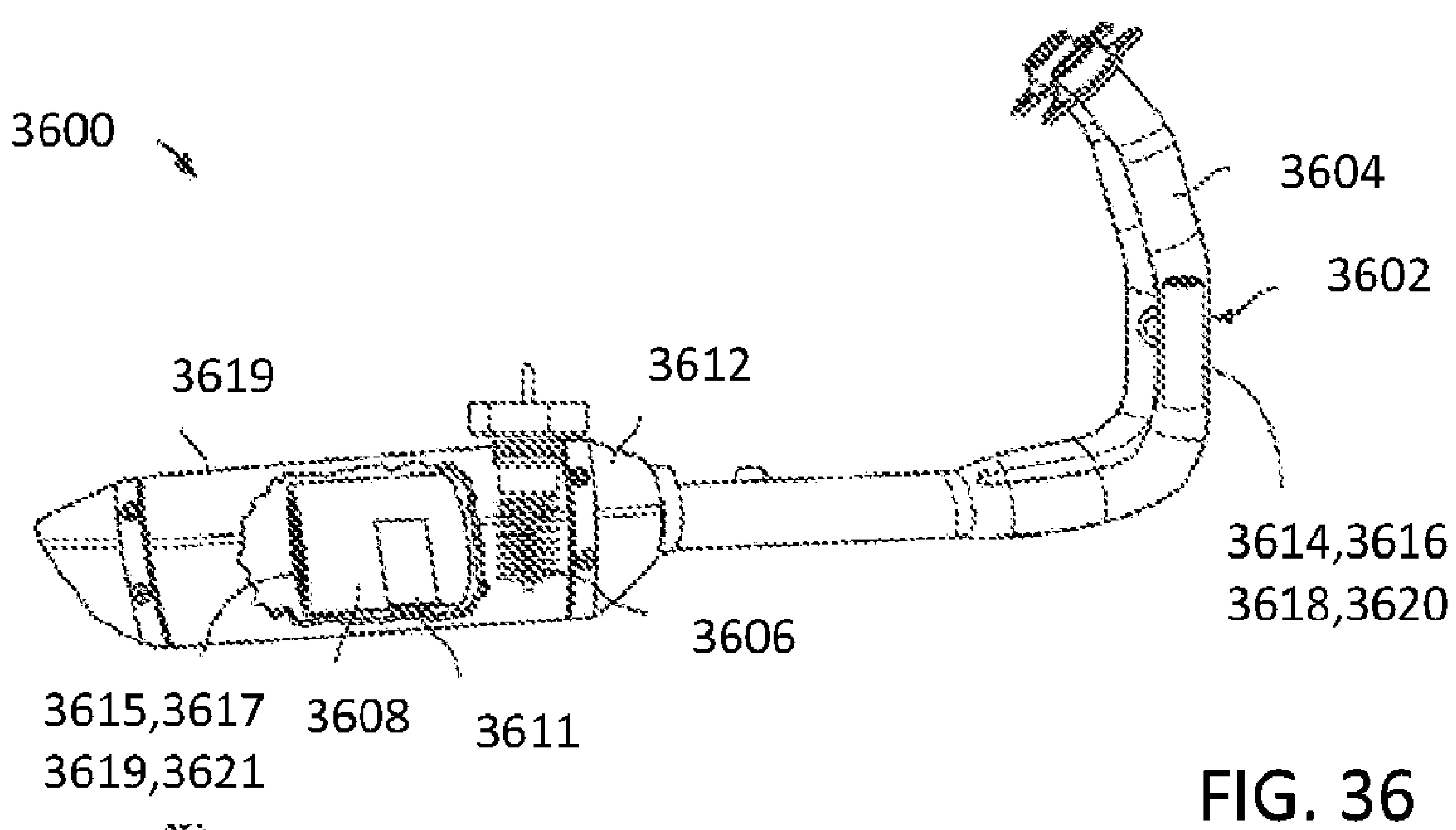


FIG. 36

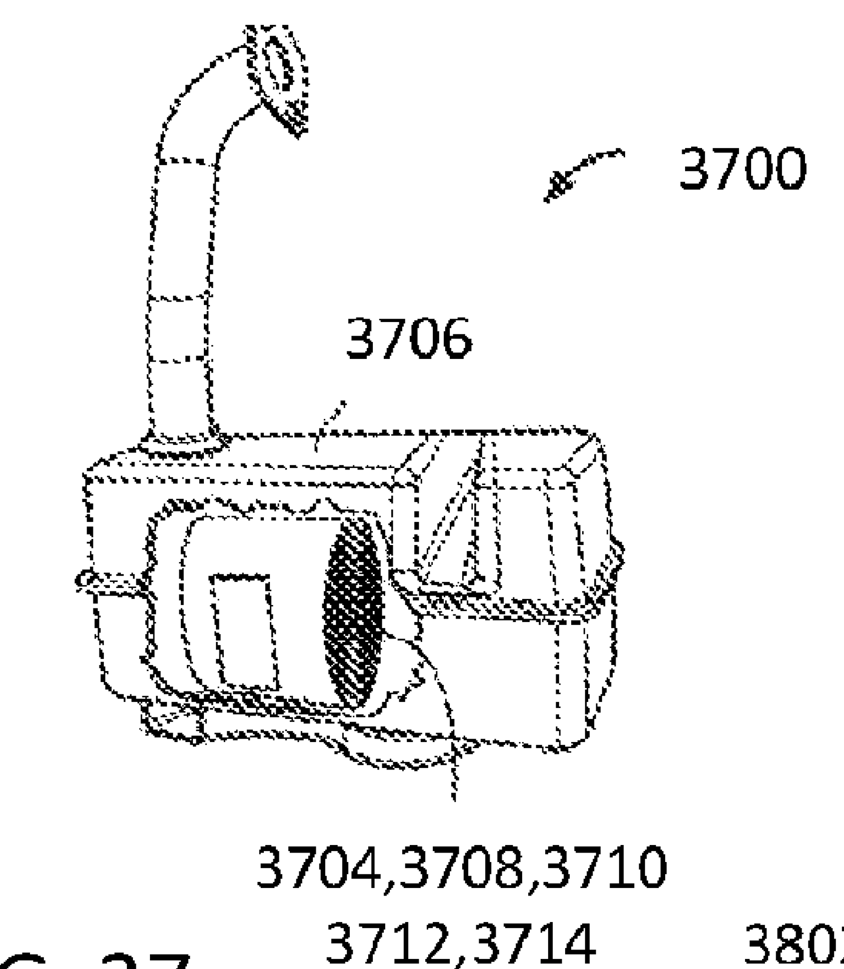


FIG. 37

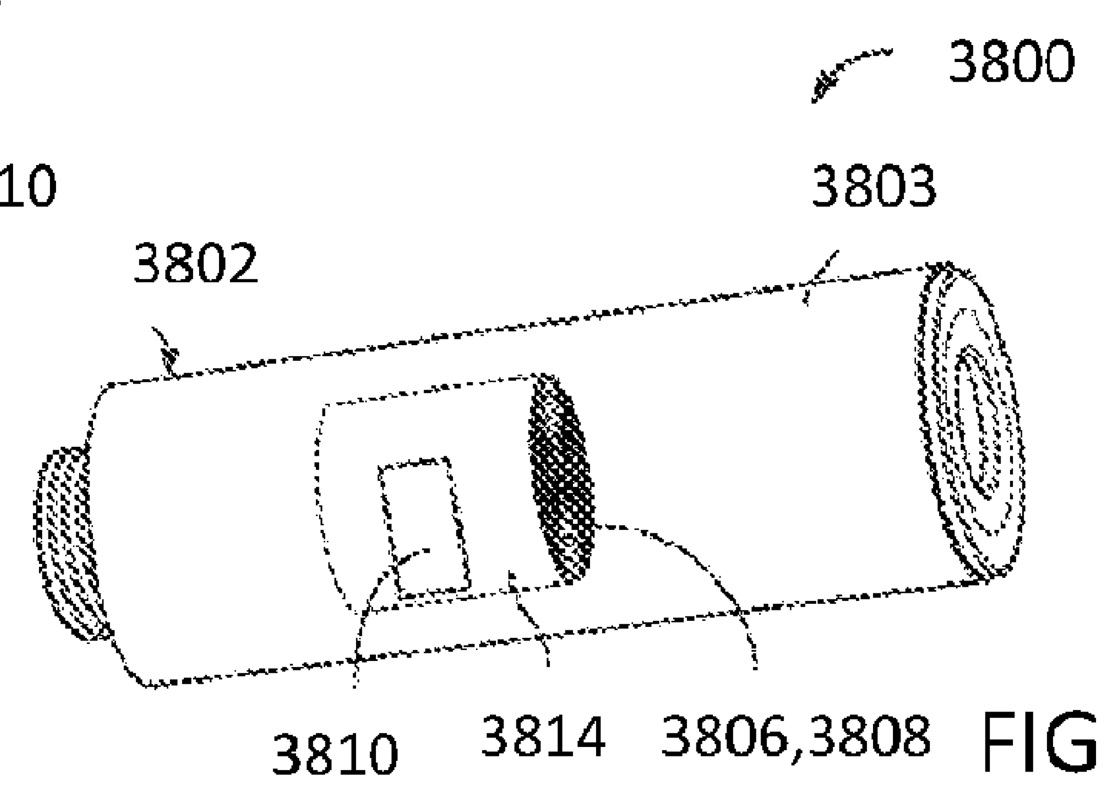
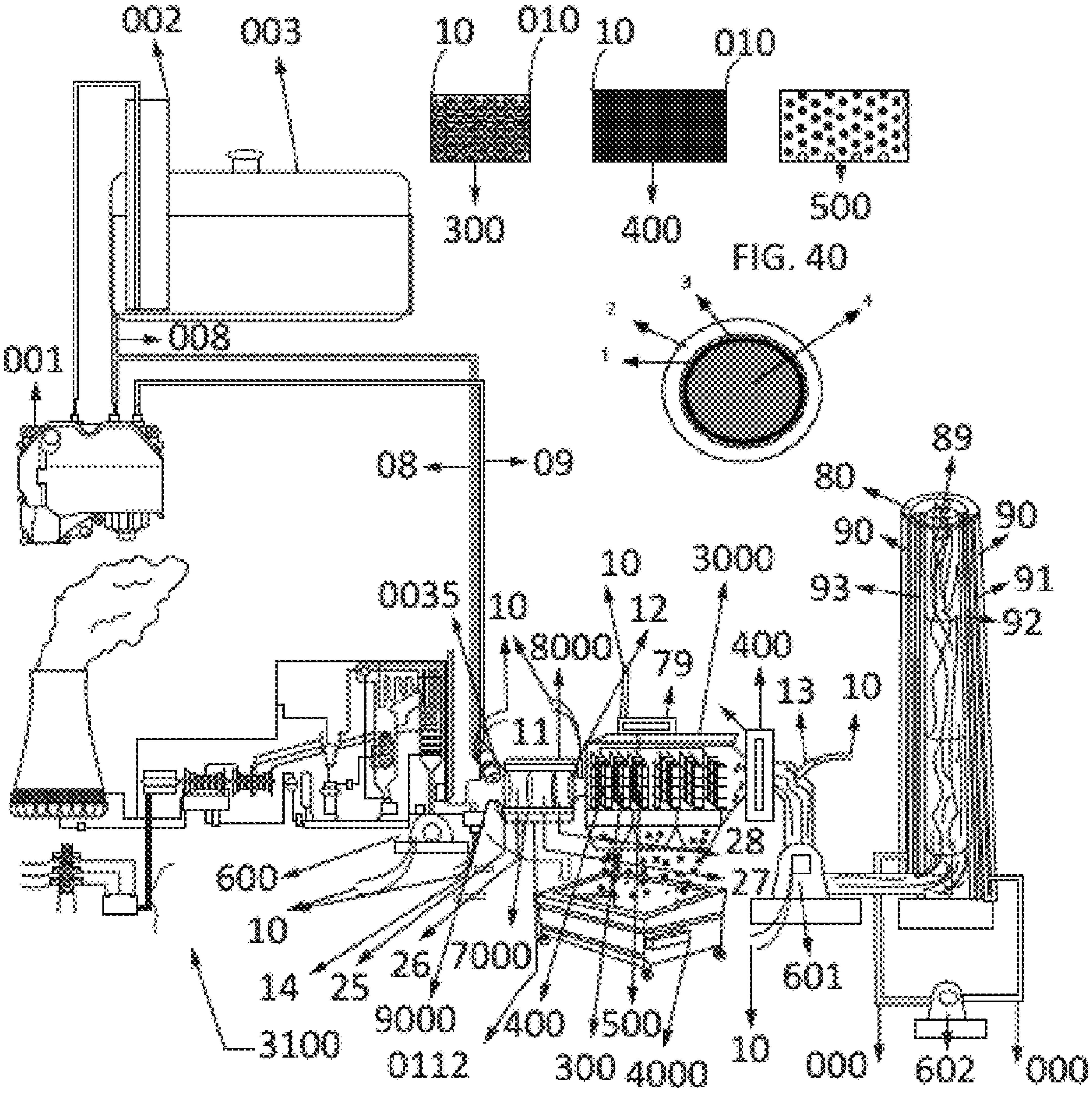


FIG. 38

FIG. 39

FIG. 40


002
003
10
010
300
400
500
001
008
08
09
0035
10
8000
12
79
3000
400
13
11
28
27
600
14
25
26
7000
9000
0112
300
500
4000
601
3100
89
80
90
91
93
92
000
602

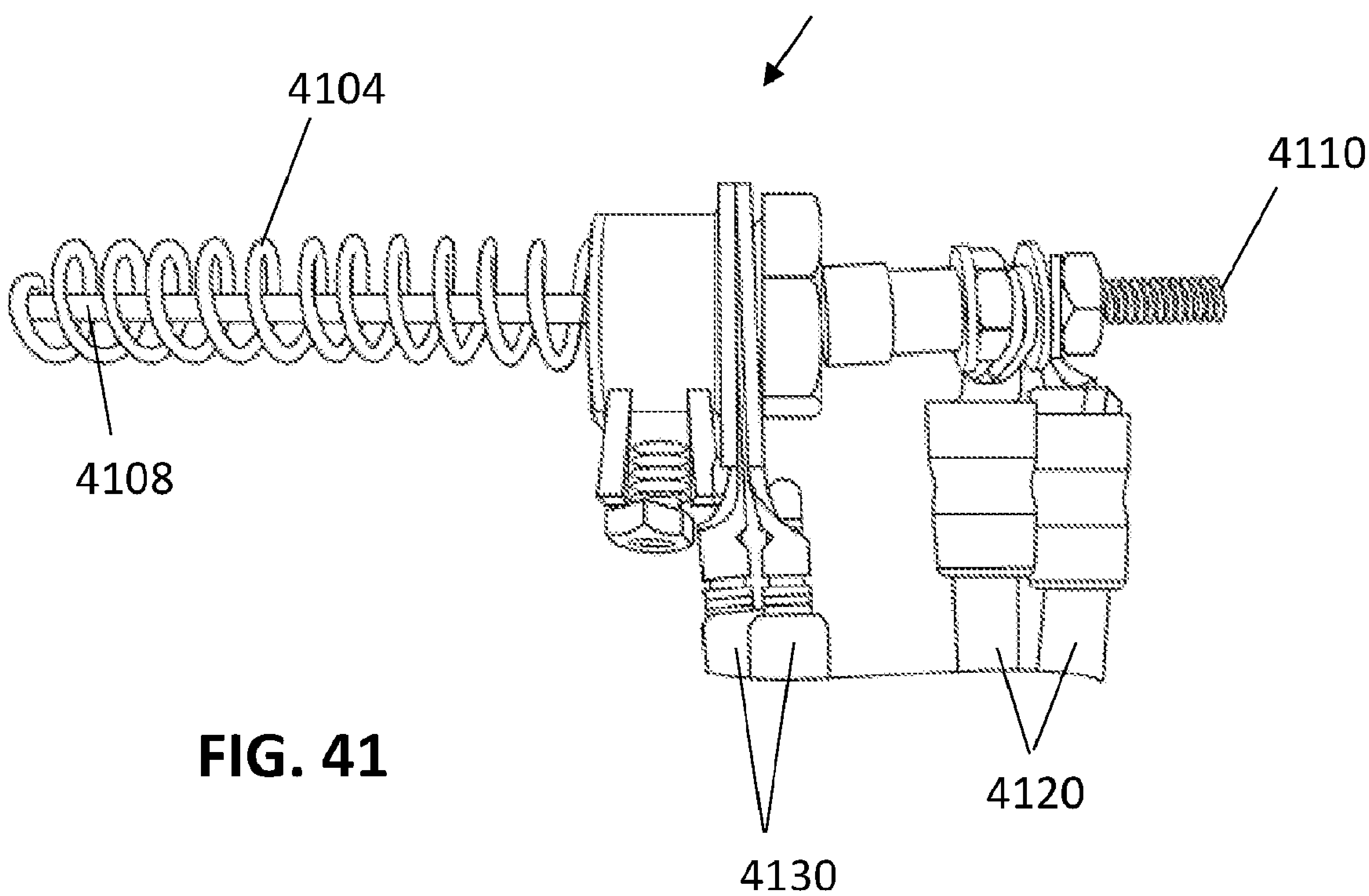


FIG. 41

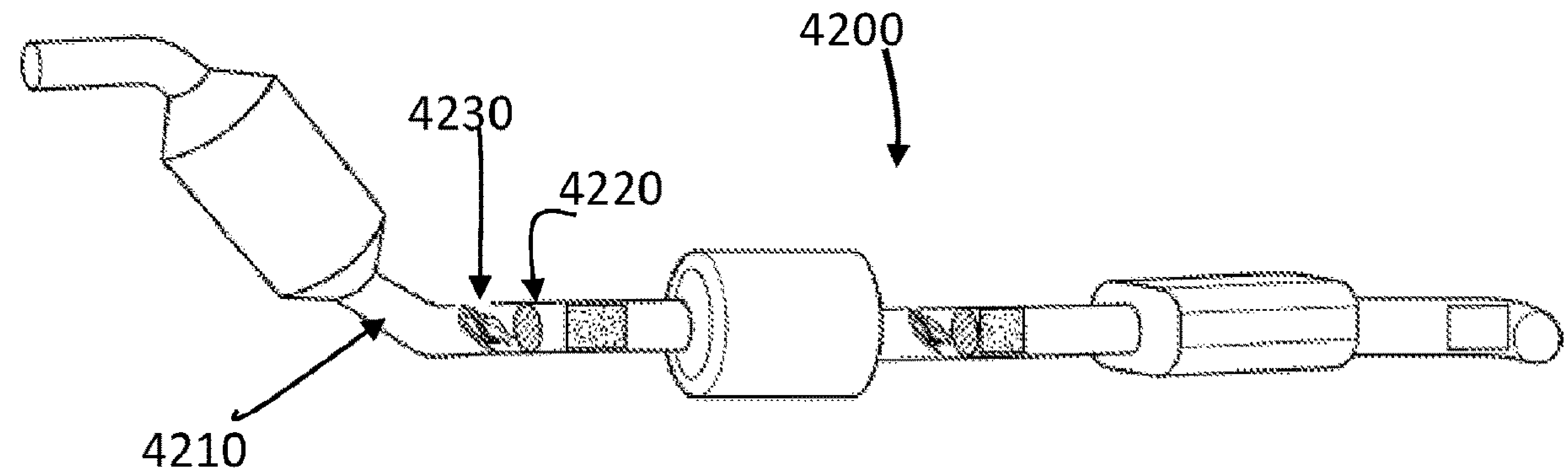

4200
4230
4220
4210

FIG. 42

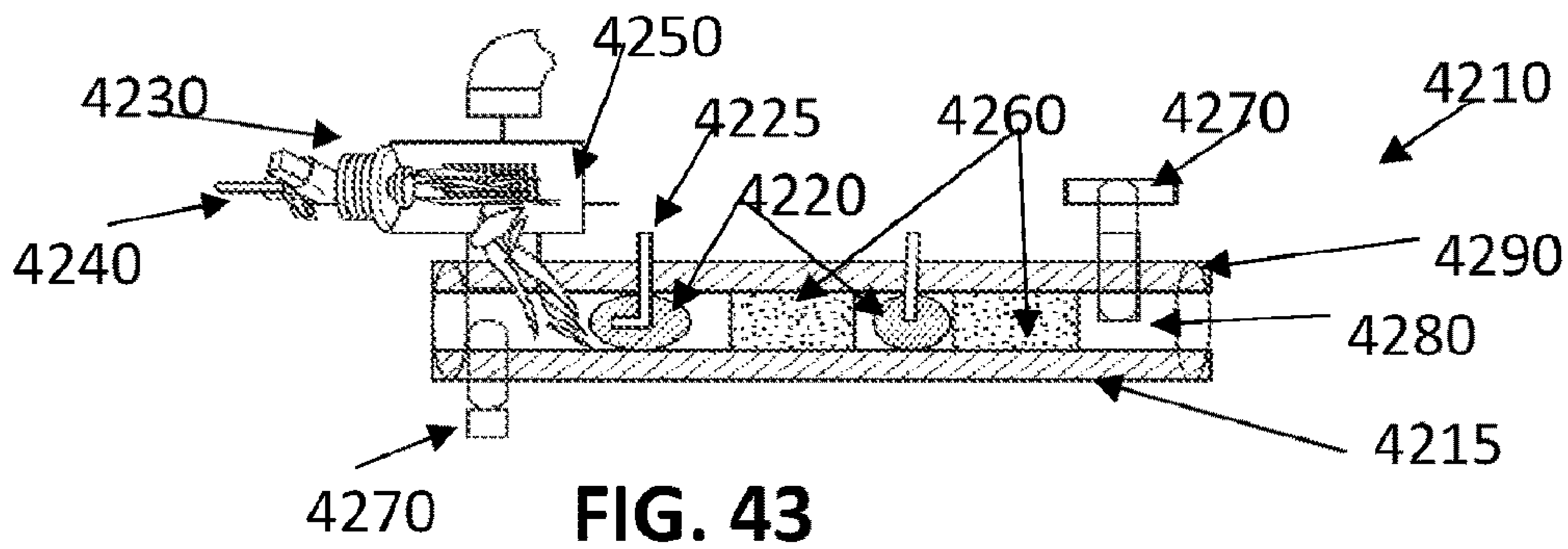

4250
4230
4225
4260
4270
4210
4220
4240
4290
4280
4215
4270

FIG. 43

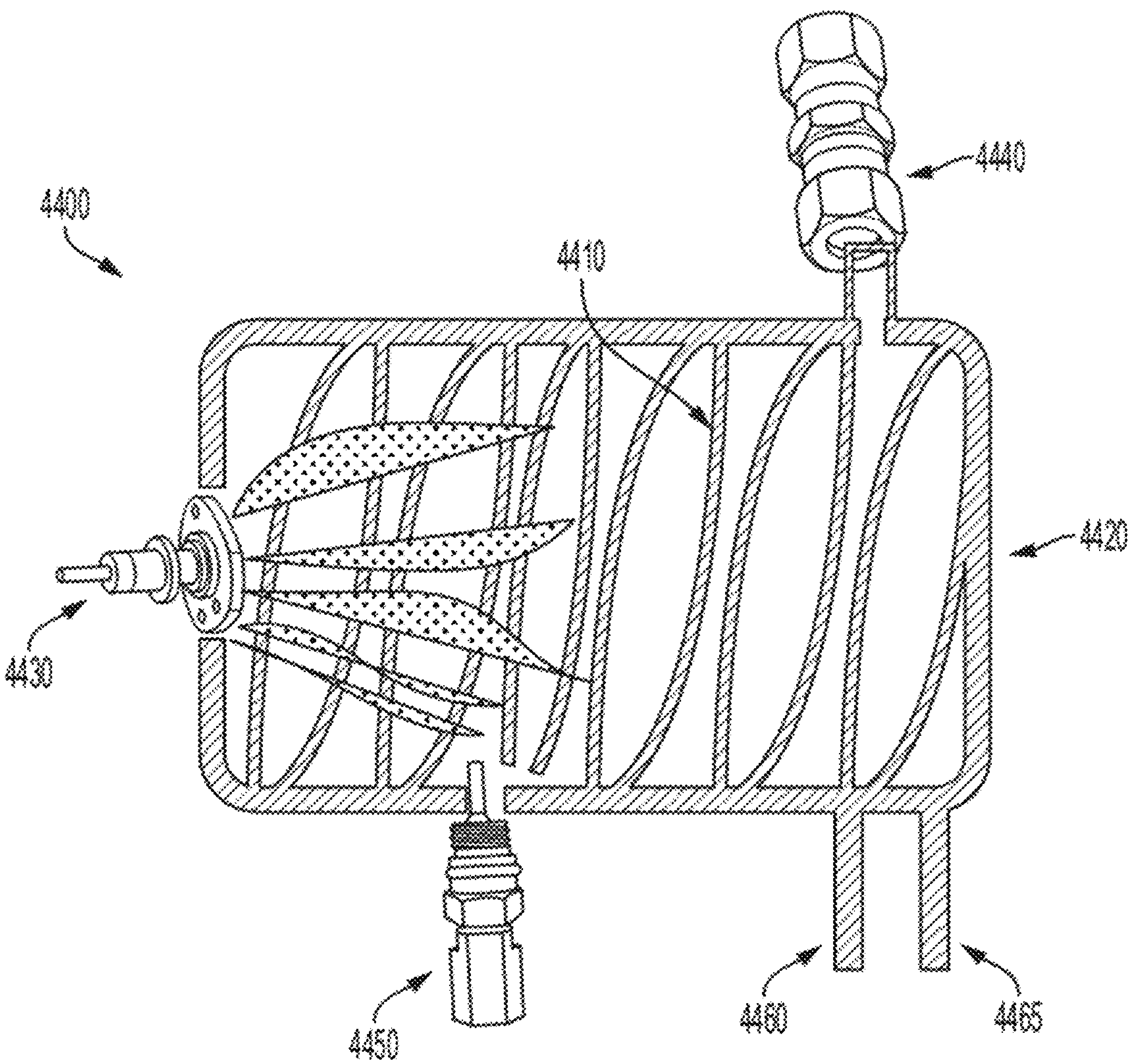


FIG. 44

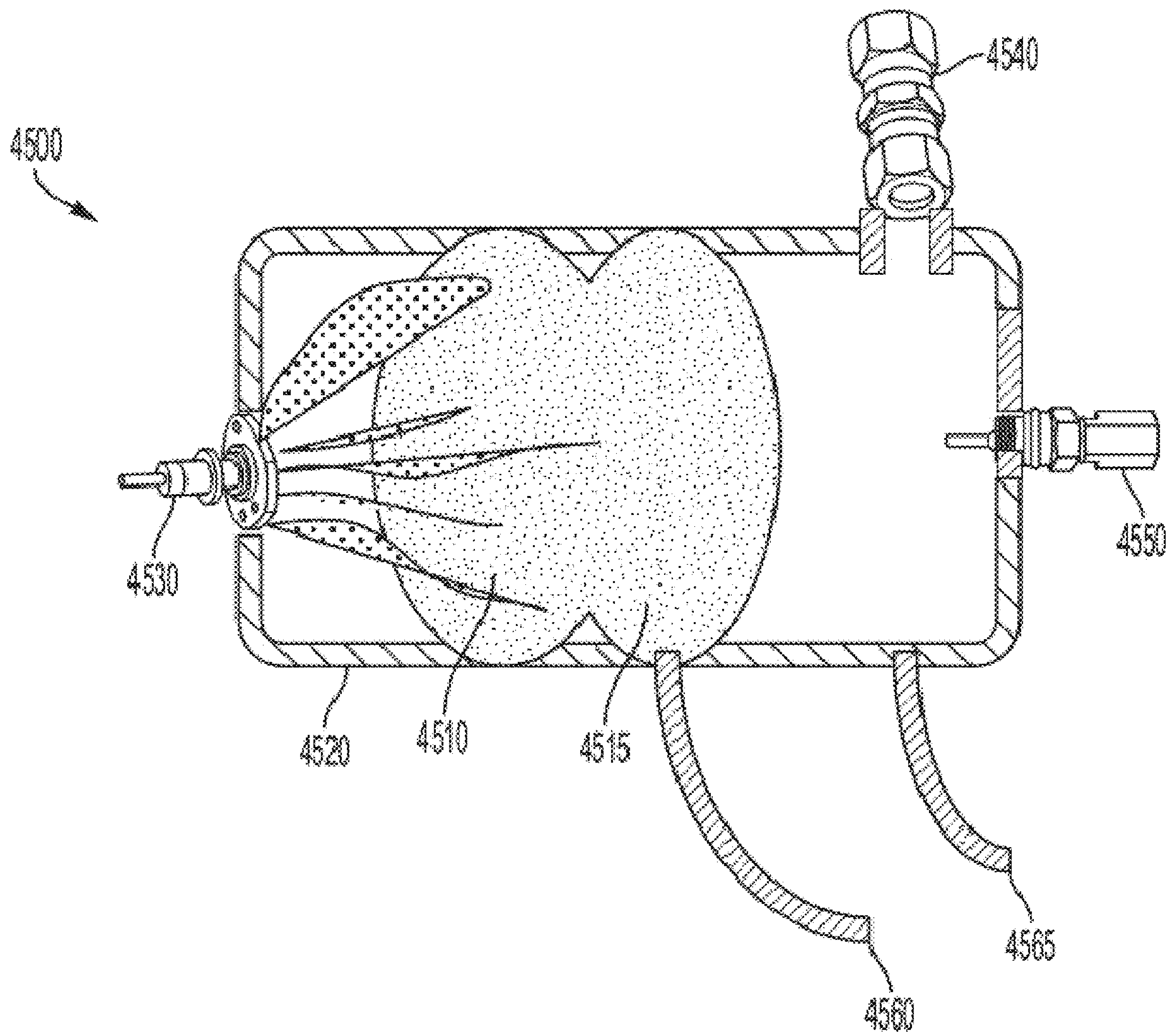


FIG. 45

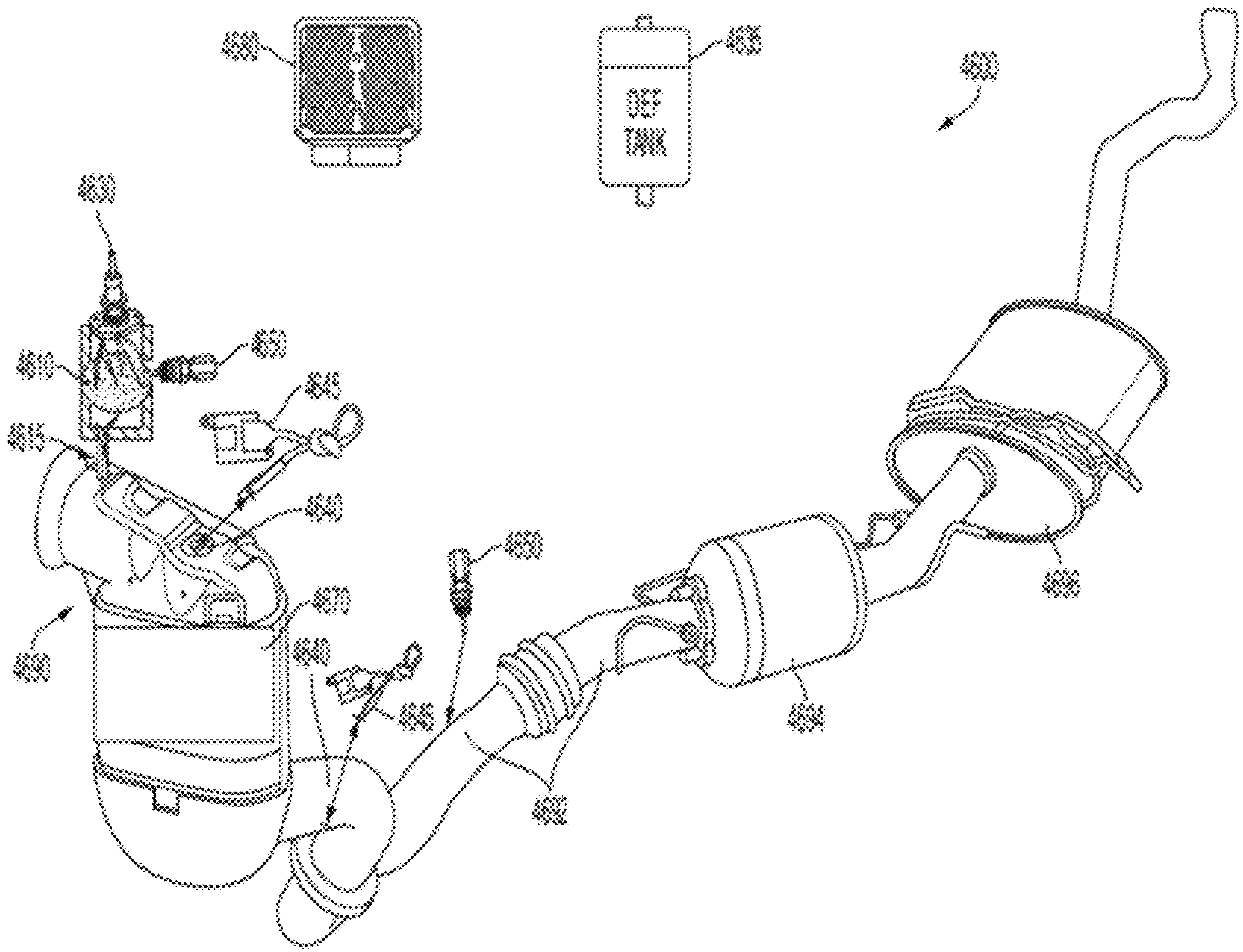


FIG. 46

EXHAUST SYSTEM AND COMPONENTS THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation application of U.S. patent application Ser. No. 18/267,261, filed on Jun. 14, 2023, which is a National Stage of PCT/US22/40366, filed on Aug. 15, 2022, which claims priority to U.S. Provisional Application No. 63/233,019, filed on Aug. 13, 2021 under 35 U.S.C. § 119(e), the entire contents of all of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to exhaust systems and more particularly to improvements to exhaust systems for removing and/or reducing harmful exhaust gases, particulate matters, and other debris that may be generated or emitted from an engine.

BACKGROUND OF THE INVENTION

Details in the background section do not constitute the related art but are given only as background information concerning the subject matter of the present disclosure.

Among the air pollutants gasoline and diesel engines emit are oxides of nitrogen-NO and NO_2, generically abbreviated as NOx. Nitrogen oxides have harmful direct effects on human health, and indirect effects through the damage they do to agricultural crops and ecosystems. Vehicle NOx emissions have been regulated since the 1960s.

NOx reacts with atmospheric chemicals to form secondary fine particulate matter (PM2.5), or soot. Exposure to PM2.5 can cause stroke, ischemic heart disease, chronic obstructive pulmonary disease, lung cancer, and lower respiratory infections. When combined with volatile organic compounds and sunlight, NOx helps form ground-level ozone, a major component of smog. Ozone can cause or exacerbate chronic lung diseases like asthma, chronic obstructive pulmonary disease, or emphysema, especially among vulnerable populations like children and the elderly, for whom it may prove deadly.

NOx emissions also affect ecosystems and agricultural crops. Ozone pollution is toxic to plants and contributes to loss of biomass, crop yields, and forest productivity. Such pollution reduces solar irradiation, decreasing photosynthesis in plants and reducing their biomass. The loss in biomass means less carbon is sequestered in plants, leaving more CO_2 in the atmosphere. Such pollution can directly change the way ecosystems work by affecting the exchange of CO_2 and water vapor across the surface of leaves, which can have significant effects on hydrology-even changing stream flows.

NOx in diesel exhaust is a particularly hard problem. Creation of some amount of NOx in the combustion process is unavoidable. The basic problem with NOx emissions from vehicles is, therefore, first to minimize the amount created, and second to remove NOx from the exhaust. The first task is mainly accomplished by lowering combustion temperature. The second is accomplished using an aftertreatment device to cause a chemical reaction reducing NOx in the exhaust to nitrogen and water and/or CO_2.

Too much oxygen present in the vehicle exhaust makes it more difficult for that chemical reaction to occur. Problem-

atically, too little oxygen makes it more difficult to get rid of other pollutants in the exhaust, unburned hydrocarbons and carbon monoxide.

Diesel engines, because of their compression-ignition design, use much more combustion air, and diesel engine exhaust consequently contains much more oxygen than gasoline engine exhaust (more oxygen in, more oxygen out). That is an unfavorable environment for the chemical reaction reducing NOx to take place in. The technical challenges related to NOx control presented by light-duty and heavy-duty diesel vehicles differ. The relative lack of physical space in which to install emissions-control equipment is a key challenge for cars, especially small cars.

Exhaust systems for fossil fuel burning engines (e.g., internal combustion engines) typically include one or more catalytic converters and a muffler connected thereto. The exhaust systems with one or more catalytic converters include, but are not limited to, various vehicles (e.g., automobiles, trucks, buses, all-terrain vehicles (ATVs), etc.), as well as electric generators, forklifts, mining equipment, trains, motorcycles, jet skis, snow mobiles, leaf blowers, aircraft, wood stoves, etc.

Generally, a catalytic converter is configured to reduce and/or convert toxic gases and pollutants of exhaust gas into less toxic pollutants by catalyzing a redox reaction (oxidation or reduction).

Modern gasoline-engine vehicles are equipped with a three-way catalytic converter as part of the exhaust system. It's called a three-way catalytic converter because it controls three pollutants: carbon monoxide (CO), which combines with oxygen in the converter to become CO_2; unburned hydrocarbons, which combine with oxygen to produce CO_2 and water vapor (H_{2O}); and NOx, which is reduced over the catalyst to nitrogen and water and/or CO_2.

Three-way catalytic converters are effective when an engine operates within a narrow band of air-fuel ratios near stoichiometry such that the exhaust gas oscillates between rich (excess fuel) and lean (excess oxygen) conditions, which may be between about 14.6 and 14.8 parts air to 1 part fuel by weight for gasoline. The ratios for liquefied petroleum gas (LPG), natural gas, and ethanol fuels is each slightly different, requiring modified fuel system settings when using those fuels. However, conversion efficiency falls very rapidly when the engine is operated outside of the narrow band of air-fuel ratios.

Because the problem of controlling NOx in diesel exhaust is more complicated, diesel vehicles require different approaches. To begin with, most modern diesel vehicles incorporate exhaust-gas recirculation (EGR) into their design. EGR systems recycle a portion of the exhaust gas back into the combustion chamber, where it combines with "fresh" intake air. This reduces the oxygen content and increases the water vapor content of the combustion mixture. That has the effect of reducing peak combustion temperature. Because more NOx is created as peak combustion temperature rises, EGR effectively reduces the amount of NOx produced by the engine. However, recycling too much of the exhaust gas increases PM2.5 and reduces fuel efficiency, so proper design entails a delicate balance.

EGR addresses the problem of controlling NOx emissions inside the engine cylinder, at the point where NOx forms. Two methods are used in diesel vehicles to control NOx after the exhaust has permanently exited the engine. A lean NOx trap (LNT) uses a catalyst to temporarily store NOx from the exhaust. At intervals (ranging from seconds to minutes, depending on operating conditions), the engine controller briefly increases the proportion of fuel in the air-fuel mixture being combusted. The exhaust from burning the richer air-fuel mixture contains proportionally less oxygen and more unburned hydrocarbons, and the stored NOx at the catalyst reacts with hydrocarbons in the exhaust to produce nitrogen and water and/or CO_2. Selective catalytic reduction (SCR) reduces NOx over a catalyst using ammonia as the reductant. The ammonia is typically supplied in the form of urea, which must be stored in solution in a tank on the vehicle. For reasons relating to engine size, operating characteristics, and the cost of raw materials for the catalyst, as a practical matter heavy-duty vehicles being produced today use only SCR systems and light-duty vehicles can use either SCR or LNT.

EGR, LNT, and SCR are active systems, in contrast to the three-way catalytic converter. Their operation is controlled by the vehicle's engine control unit (which determines, for example, the intervals at which urea solution is injected into the exhaust for SCR, or the air-fuel mixture is enriched to regenerate the LNT) and they come with maintenance requirements and costs both direct (e.g., a service charge to refill a urea tank) and indirect (slightly reduced fuel economy from running the engine rich periodically or from recirculating exhaust gas).

When operating a gasoline or diesel vehicle at low temperatures (e.g., during engine cold-start), exhaust systems devices are generally not catalytically active enough to reduce engine emissions, such as hydrocarbons and NOx. Cold-start emissions—the dangerous gases produced during the first 60 seconds or so after ignition—represent the most toxic segment of the engine operating cycle. In fact, more than 70 percent of all the harmful gas emissions from a single average drive come during this cold-start immediately after start-up. That is because catalysts typically do not reach full efficiency until the engine exhaust gas heats the catalyst up to the temperature at which catalytic reactions are initiated within the catalytic converter. Since catalysts require a certain temperature (typically above 300° C.) to work to full efficiency, emissions are significantly higher during the warm-up phase of the car. The duration of this period and the emissions produced depend on the ambient temperature as well as on the initial temperature of the car's propulsion systems. Indeed, for gasoline cars, in average real-world driving conditions the majority of the CO (carbon monoxide) and HC (hydrocarbon) total emissions are due to cold-start extra emissions. Moreover, the cold-start emissions increase considerably at lower ambient temperatures. In contrast, cold-start emissions of diesel cars are lower than those of gasoline cars. Thus there exists a need to heat the catalytic converter fast such that catalytic ignition occurs almost from the moment of engine start-up.

The present disclosure is directed to overcoming one or more of the above-referenced challenges. The background description provided herein is for the purpose of generally presenting the context of the disclosure. Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art, or suggestions of the prior art, by inclusion in this section.

SUMMARY OF THE INVENTION

According to certain aspects of the disclosure, systems and methods are disclosed for improving removal and/or reduction of harmful exhaust gases, particulate matters, and other debris from an exhaust system.

In one embodiment, there is a heater for an exhaust system, the heater including a housing including a connector

coupled to the exterior of the housing, and a first terminal and a second terminal, each disposed to the interior of the housing and electrically coupled to the connector; a heating element coupled to the first and second terminals; a heating wire coupled to the first and second terminals; and a plurality of heating rods inserted through openings in the heating element to conduct heat from the heating wire throughout the heating element, at least one of the heating rods to support the heating wire, wherein the connector is configured to receive power from a power supply that is external from the heater to supply electrical current to the heating element and the heating wire.

In one embodiment, the heating element includes a catalytic coating having two or more layers of noble metals.

In one embodiment, the noble metals include two or more of platinum, titanium, palladium, rhodium and gold.

In one embodiment, the catalytic coating includes: a first layer comprising titanium; a second layer comprising palladium that is disposed on the first layer; a third layer comprising rhodium that is disposed on the second layer; and an outermost layer comprising a ceramic material.

In one embodiment, the heating wire is displaced in at least two planes parallel to each other.

In one embodiment, the heating wire includes a first heating wire and a second heating wire, the first heating wire displaced from the second heating wire.

In one embodiment, the displacement between the first and second heating wires is orthogonal to the planes of the first and second heating wires.

In one embodiment, one or more of the heating rods include a rod portion and a tip portion.

In one embodiment, the tip portion is formed of an insulative material such that electrical current does not transfer from the heating wire to the rod.

In one embodiment, one or more of the heating rods includes a fastener disposed at the tip portion thereof, the fastener configured to support the heating wire.

In one embodiment, the fastener is formed of an insulative material such that electrical current does not transfer from the heating wire to the rod.

In one embodiment, the heating rods include a first length heating rod having a first length and a second length heating rod having a second length that is different than the first length, wherein the first length heating rod supports the heating wire at a first displacement and the second length heating rod supports the heating wire at a second displacement.

In one embodiment, the heating rods have at least two lengths.

In one embodiment, the heater is provided inside a catalytic converter.

In one embodiment, the heater is provided inside a cavity of an exhaust pipe of the exhaust system.

In one embodiment, the exhaust pipe is located between at least one of an exhaust manifold and a catalytic converter, or the catalytic converter and a selective catalytic reduction system (SCR), or the SCR and a muffler of the exhaust system.

In one embodiment, the exhaust pipe is located between at least one of a diesel oxidation catalyst and a diesel particulate filter (DPF), or between the DPF and a selective catalytic reduction system (SCR), or between the SCR and a muffler of the exhaust system.

In one embodiment, the exhaust pipe further includes a dosing system having a dosing solution injector and a dosing solution reservoir that houses a dosing solution, wherein the dosing solution injector is configured to spray the dosing solution towards the heater.

In one embodiment, the heater is configured to receive signals from a controller to control an amount of current supplied to the heater and the timing in which the current is supplied to the heater.

In one embodiment, the dosing system is configured to receive signals from the controller to control a timing and a duration of the dosing solution spray, whereby the supplied current and the timing and the duration of the dosing solution spray are based on one or more sensors located within the exhaust pipe.

In one embodiment, the exhaust pipe further includes a plurality of magnets arranged adjacent to an exterior surface of the exhaust pipe to aid in disruption and slowing of the flow of exhaust gases in the cavity of the exhaust pipe.

In one embodiment, the exhaust pipe includes a second surface positioned outside of the exterior surface and the plurality of magnets are arranged between the second surface and the exterior surface of the exhaust pipe.

In one embodiment, the plurality of magnets are neodymium magnets.

In one embodiment, the heating wire are formed of nickel and chromium.

In one embodiment, the connector is isolated from the housing by a ceramic spacer.

In one embodiment, the one or more of the openings of the heating element has a honeycomb or hexagonal shape.

In one embodiment, there is a structure that includes: an exhaust pipe configured to be coupled to an exhaust system component, the exhaust pipe including a heater disposed inside a cavity of the exhaust pipe, the heater including: a housing, a heating wire disposed inside the housing, and a connector attached to the housing and electrically connected to the heating wire, wherein the connector is configured to receive power from a power supply that is external from the heater to supply electrical current to the heating wire, whereby the heater is configured to heat gas inside the exhaust pipe to reduce toxic gases and/or particulate matter exiting the exhaust pipe.

In one embodiment, the exhaust system component includes one or more of the following: an exhaust manifold, a catalytic converter, a selective catalytic reduction system (SCR), a diesel oxidation catalyst, a diesel particulate filter (DPF), a selective catalytic reduction system (SCR), and a muffler.

In one embodiment, the exhaust pipe includes a plurality of magnets arranged adjacent to an exterior surface of the exhaust pipe to aid in disruption and slowing of the flow of exhaust gases in the cavity of the exhaust pipe.

In one embodiment, the exhaust pipe further includes a second surface positioned outside of the exterior surface and the plurality of magnets are disposed between the second surface and the exterior surface of the exhaust pipe.

In one embodiment, a structure includes a heater configured to be connected external to a component of a vehicle exhaust system, the heater including a housing, a heating element, and a sensor; and a magnet configured to be arranged adjacent to an exterior surface of the component to aid in disruption and slowing of the flow of exhaust gases in the component.

In one embodiment, the component is a catalytic converter.

In one embodiment, the component is one or more of the following: an exhaust manifold; a catalytic converter; a selective catalytic reduction system (SCR); a diesel oxidation catalyst; a diesel particulate filter (DPF); a selective catalytic reduction system (SCR); a muffler; and an exhaust system pipe.

In one embodiment, the heater includes a first heater configured to be connected external to a catalytic converter and a second heater configured to be connected external to a SCR.

In one embodiment, the heater further comprises a dosing system that includes a dosing solution injector and a dosing solution reservoir that houses a dosing solution, the dosing solution injector configured to spray the dosing solution towards the component.

In one embodiment, the sensor includes one or more temperature sensors and one or more gas sensors.

In one embodiment, the structure further includes a component gas sensor configured to be coupled to the component.

In one embodiment, the structure further includes an exhaust pipe gas sensor configured to be coupled to an exhaust pipe attached to an outlet port of the component.

In one embodiment, the structure further includes an exhaust pipe temperature sensor configured to be coupled to an exhaust pipe attached to an outlet port of the component.

Specific effects are described along with the above-described effects in the section of Detailed Description.

Aspects, features, and advantages of the present disclosure are not limited to those described above. It is understood that other aspects, features, and advantages not mentioned above can be clearly understood from the following description and can be more clearly understood from the embodiments set forth herein. Additionally, it is understood that various aspects, features, and advantages described herein can be realized via means and combinations thereof that are described in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate various exemplary embodiments and together with the description, serve to explain the principles of the disclosed embodiments.

FIG. **1** is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. **2**A is a side view of a filter of the catalytic converter of FIG. **1**, according to one or more embodiments of the present disclosure;

FIG. **2**B is a cross-sectional view of a catalyst coating of the catalytic converter of FIG. **1**, according to one or more embodiments of the present disclosure.

FIG. **3** is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIGS. **4**A-**4**B are side views of disruptor plates of the catalytic converter of FIG. **3**, according to one or more embodiments of the present disclosure;

FIG. **4**C is a side view of a filter of the catalytic converter of FIG. **3**, according to one or more embodiments of the present disclosure;

FIG. **5** is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. **6** is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. 7 is an arrangement of the external magnets of the catalytic converter of FIG. 6, according to one or more embodiments of the present disclosure;

FIG. 8 is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. 9A is a cross-sectional view of one of the internal magnets of the catalytic converter of FIG. 8, according to one or more embodiments of the present disclosure;

FIG. 9B is an exploded view of the internal magnets of the catalytic converter of FIG. 8, according to one or more embodiments of the present disclosure;

FIG. 10 is a cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. 11A is a side view of a filter of the catalytic converter of FIG. 10, according to one or more embodiments of the present disclosure;

FIG. 11B is a perspective view of a filter of the catalytic converter of FIG. 10, according to one or more embodiments of the present disclosure;

FIG. 12 is a perspective cutaway view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. 13 is a partial cross-sectional view of a catalytic converter, according to one or more embodiments of the present disclosure;

FIG. 14 is a perspective cutaway view of a selective catalytic reduction system, according to one or more embodiments of the present disclosure;

FIG. 15A is an end view of a filter for the selective catalytic reduction system of FIG. 14, according to one or more embodiments of the present disclosure;

FIG. 15B is a sectional view of the filter of the selective catalytic reduction system of FIG. 14, according to one or more embodiments of the present disclosure;

FIG. 16 is a perspective assembly view of an exhaust system or an internal combustion engine that runs on gasoline, according to one or more embodiments of the present disclosure;

FIG. 17 is a partial cutaway view of an exhaust system converter, according to one or more embodiments of the present disclosure;

FIG. 18A is a perspective view of a heater, according to one or more embodiments of the present disclosure;

FIG. 18B is a perspective view of a heater, according to one or more embodiments of the present disclosure;

FIG. 18C is a perspective view of heaters, according to one or more embodiments of the present disclosure;

FIG. 19 is a perspective view of a heater, according to one or more embodiments of the present disclosure;

FIG. 20 is a perspective view of a heater, according to one or more embodiments of the present disclosure;

FIG. 21 is a perspective view of a heating pin, according to one or more embodiments of the present disclosure;

FIG. 22 is a cross-sectional view of a catalytic convert of showing heaters, according one or more embodiments of the present disclosure;

FIGS. 23 and 24 are a perspective and end view of a coil heater, according to one or more embodiments of the present disclosure;

FIG. 25 is a top view of a muffler, according to one or more embodiments of the present disclosure;

FIG. 26 is a sectional the muffler of FIG. 25, according to one or more embodiments of the present disclosure;

FIG. 27 shows an exemplary exhaust system, according to one or more embodiments of the present disclosure;

FIG. 28 shows an exemplary exhaust system, according to one or more embodiments of the present disclosure;

FIG. 28A shows an exemplary dosing solution distributor, according to one or more embodiments of the present disclosure;

FIG. 29 shows a schematic view of an exemplary exhaust control system, according to one or more embodiments of the present disclosure;

FIGS. 30A-30C show an exhaust system for a vehicle that runs on diesel fuel, according to one or more embodiments of the present disclosure;

FIG. 31 is a perspective cutaway view of an oxidation catalyst, according to one or more embodiments of the present disclosure;

FIG. 32 is an end view of a filter arranged in an oxidation catalyst, according to one or more embodiments of the present disclosure;

FIG. 33 is an end view of a filter arranged in a diesel particulate filter, according to one or more embodiments of the present disclosure;

FIG. 34 is an assembly view of an exhaust system for a coal related application, according to one or more embodiments of the present disclosure;

FIGS. 35A and 35B are front views of a filter arranged in the catalytic converter of the exhaust system of FIG. 35;

FIG. 36 is an exhaust system for a motorcycle, according to one or more embodiments of the present disclosure;

FIG. 37 is an exhaust system for a lawnmower, according to one or more embodiments of the present disclosure; and

FIG. 38 is a non-battery operated exhaust system, according to one or more embodiments of the present disclosure;

FIG. 39 is an assembly view of an exhaust system for an industrial power plant, according to one or more embodiments of the present disclosure;

FIG. 40 is a top view of the smoke stack shown in FIG. 34, according to one or more embodiments of the present disclosure.

FIG. 41 is a view of a coil heater, according to one or more embodiments of the present disclosure;

FIGS. 42 and 43 are assembly views of an exhaust system having an exhaust pipe heater, according to one or more embodiments of the present disclosure;

FIG. 44 is a view of an external heater, according to one or more embodiments of the present disclosure;

FIG. 45 is a view of an external heater, according to one or more embodiments of the present disclosure; and

FIG. 46 is an assembly view of an exhaust system having one or more external heaters, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The subject matter of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, which form a part thereof, and which show, by way of illustration, specific exemplary embodiments. An embodiment or implementation described herein as "exemplary" is not to be construed as preferred or advantageous, for example, over other embodiments or implementations; rather, it is intended to reflect or indicate that the embodiment(s) is/are "example" embodiment(s). Subject matter can be embodied in a variety of different forms and, therefore, covered or claimed subject matter is intended to be construed as not being limited to any exemplary embodiments set forth herein; exemplary embodiments are provided merely to be illustrative. Likewise, a reasonably broad scope for claimed or covered subject matter is intended. Among other things, for example, subject matter may be embodied as methods, devices, components, or systems. Accordingly, embodiments may, for example, take the form of hardware, software, firmware, or any combination thereof (other than software per se). The following detailed description is, therefore, not intended to be taken in a limiting sense.

Throughout the specification and claims, terms may have nuanced meanings suggested or implied in context beyond an explicitly stated meaning. Likewise, the phrase "in one embodiment" as used herein does not necessarily refer to the same embodiment and the phrase "in another embodiment" as used herein does not necessarily refer to a different embodiment. It is intended, for example, that claimed subject matter include combinations of exemplary embodiments in whole or in part.

The terminology used below may be interpreted in its broadest reasonable manner, even though it is being used in conjunction with a detailed description of certain specific examples of the present disclosure. Indeed, certain terms may even be emphasized below; however, any terminology intended to be interpreted in any restricted manner will be overtly and specifically defined as such in this Detailed Description section. Both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the features, as claimed.

In this disclosure, the term "based on" means "based at least in part on." The singular forms "a," "an," and "the" include plural referents unless the context dictates otherwise. The term "exemplary" is used in the sense of "example" rather than "ideal." The term "or" is meant to be inclusive and means either, any, several, or all of the listed items. The terms "comprises," "comprising," "includes," "including," or other variations thereof, are intended to cover a non-exclusive inclusion such that a process, method, or product that comprises a list of elements does not necessarily include only those elements, but may include other elements not expressly listed or inherent to such a process, method, article, or apparatus. Relative terms, such as, "substantially" and "generally," are used to indicate a possible variation of 5% of a stated or understood value.

With reference now to the drawings, and in particular to FIGS. **1-41**, embodiments of exhaust systems and associated features thereof embodying the principles and concepts of the present disclosure will be described.

A catalytic converter includes one or more filters. The filter may be formed of ceramic and include openings that are honeycomb-shaped (not limited to any particular shape). In applications where particularly high heat resistance is required, metallic foil monolithic filters made of Kanthal (FeCrAl) may be used. Catalytic converters may include a catalyst coating formed of aluminum oxide, titanium dioxide, silicon dioxide, or a mixture of silica and alumina. The catalyst materials may be selected to form a rough, irregular surface, which greatly increases the surface area compared to the smooth surface of the bare substrate. This in turn maximizes the catalytically active surface available to react with the engine exhaust. Under lean engine operation, there may be excess oxygen and the reduction of NOx may not favored. Under rich conditions, the excess fuel may consume the available oxygen prior to the catalyst, thus only stored oxygen may be available for the oxidation function. Closed-loop control systems may be necessary because of the conflicting requirements for effective NOx reduction and HC oxidation. The control system may prevent the NOx reduction catalyst from becoming fully oxidized, yet replenish the oxygen storage material to maintain its function as an oxidation catalyst.

FIG. **1** illustrates a cross-sectional view of a catalytic converter **100** according to an embodiment of the present disclosure. The catalytic converter **100** may extend along a longitudinal (or horizontal) axis **104**. The catalytic converter **100** may include an external shell **102**, an inlet port **106**, and an outlet port **108**. One or more filters **110** may be disposed inside of the external shell **102**. An internal structure having a plurality of spaces (or openings) **112** may be provided or arranged inside of the external shell **102**. For example, as shown, the spaces **112** may be provided between or adjacent the one or more filters **110**. One or more electrical heating elements **114**, which are configured to heat the inside of the catalytic converter **100**, may be arranged within the spaces **112**. The heating elements **114** may include heating wires constructed of, for example, nichrome (NiCr) wires, but are not limited thereto. Electrical leads **116** may extend from a power supply (not shown in the figures for clarity of illustration) to supply electrical energy to the heating elements **114**. The heating elements **114**, by heating the inside of the catalytic converter **100**, significantly and substantially improves the removal or reduction of harmful gases and particulate matters within the catalytic converter **100** compared to conventional catalytic converters. Although FIG. **1** is explained with respect to a catalytic converter, the components and embodiments of FIG. **1** may be directed to or incorporated into any other exhaust converter, for example, a selective catalyst reduction system, an oxidation catalyst, a diesel particulate filter, exhaust pipes, etc.

FIG. **2**A shows an end view of the filter **110**. In one embodiment, the filter **110** may be, for example, a metallic or a ceramic filter including a plurality of honeycomb shaped openings **210**. The openings **210** may be configured to communicate gas and/or particulate matters from one end to the opposite end of the filter **110**. The shape and size of the openings **210** of the filter **110** may vary depending on the application of one or more exhaust systems of the present disclosure. In one embodiment, the size of the openings **210** for the filter **110** used in a gasoline engine system may be about 1/16 inch, but is not limited thereto. In another embodiment, the size of the openings **210** for the filter **110** used in a diesel engine system may be between about 1/8 inch to 1/4 inch, but is not limited thereto.

In one embodiment, the filter **110** may be coated with catalyst coating material to maximize or increase contact between the filter **110** and the toxic or harmful gases and particulate matters. The catalyst coating material may slow down the flow of toxic gases and particulate matters that may traverse from the inlet port **106** to the outlet port **108**. Additionally, the catalyst coating material may help facilitate rapid heating of the catalytic converter **100**. Additionally, the catalyst coating material may facilitate rapid heating of the catalytic converter **100**. Embodiments of the catalyst coating and associated features thereof embodying the principles and concepts of the present disclosure are described hereinafter.

FIG. **2**B shows a cross-sectional view of a catalyst coating **220**, in accordance with an embodiment of the present disclosure. The catalyst coating **220** may include a plurality of layers **222-230**. The plurality of layers may include, for example, a first layer **222**, second layer **224**, third layer **226**, fourth layer **228**, and a fifth layer **230**. The first layer **222** may be provided on a surface of the filter **110** or comprise the surface material of the filter itself. The first layer **222** may include, for example, a ceramic material having a thickness of about 0.35 to 0.8 micrometer. The top layer—which is the fifth layer **230** in FIG. **2**B, may also include, for example, a ceramic material having a thickness of 0.35 to 0.8 micrometer. The first and fifth layers **222**, **230** comprising one or more ceramic materials may provide protection from potential impact or damage for the filter **110** and other layers of the catalyst coating **220**. The thickness of the first and fifth layers **222**, **230** are not limited thereto and depend on a particular application.

In one embodiment, the second, third, and fourth layers **224**, **226**, **228** may be sandwiched between the first layer **222** and the fifth layer **230**. Further, the second, third, and fourth layers **224-228** may include noble metals. For example, the second layer **224** may include titanium, the third layer **226** may include palladium, and the fourth layer **228** may include rhodium. Additionally or alternatively, gold may be used in addition to the layers **222-230** or in combination with one or more of the layers **222-230**. For example, gold may be sprayed (e.g., by spraying scattering spots or dots of gold) in between or on top of the layers **222-230**. When gold is utilized in the catalyst coating **220**, each or a combination of the layers **222-230** may be made thinner. That is, the effectiveness of the catalyst coating **220** may be improved by using gold in the layers **222-230**. In one exemplary embodiment of the present disclosure, the filter **110** used for a gasoline engine system may include honeycomb shaped openings coated with platinum, palladium, rhodium, and ceramic. Additionally or alternatively, gold may be used. Similarly, the filter **110** for a diesel engine system may include hexagonal or honeycomb openings coated with platinum, palladium, rhodium, and ceramic. Geometric surface area can be an important factor for catalytic performance. While not limited thereto, hexagonal shaped openings provide better thermal mass efficiency than square shaped openings.

The thickness of the second, third and fourth layers may be 0.35-0.80 micrometers; however the thickness of each layer is not limited thereto and depends on a particular application. In one embodiment, the filter **110** may be baked at a predetermined temperature after each layer of the catalyst coating **220** is applied. Although five layers are shown in FIG. 2B for the catalyst coating **220**, the number of layers for the catalyst coating **220** may not be limited to five. Additionally, the order of the second to fourth layers **224-228** may be interchangeable. However, the first and fifth layers **222**, **230** may be disposed preferably on the outer layers of the second to fourth layers **224-228** to provide protection for the noble metal layers (e.g., layers **224-228**) and the filter **110**. The catalyst coating **220** according to embodiments of the present disclosure rapidly heats up the filter **110** and dramatically reduces or removes undesirable exhaust gases and particulate matters.

In embodiments, the catalyst coating **220** may retain its surface area and may prevent sintering of the catalytic metal particles at high temperatures, for example, approximately 1000° C. or greater. As described above, the catalyst materials may be a mix of precious or noble metals. In some embodiments, platinum may be selected as the main active catalyst. Alternatively, platinum may not be used in some embodiments. Whether the platinum is used may be determined, for example, based on any unwanted additional reactions and/or costs. Additionally or alternatively, palladium and rhodium may be included in the catalyst coating **220**. In one embodiment, rhodium may be included in the catalyst coating **220** used for a reduction catalyst, and palladium may be included in the coating materials used for an oxidation catalyst. In one embodiment, platinum may be included in the catalyst coatings to facilitate reduction and/or oxidation. Additionally or alternatively, cerium, copper, iron, manganese, and nickel may be included in the coating materials to facilitate reduction and/or oxidation.

FIG. **3** illustrates a catalytic converter **300** according to an embodiment of the present disclosure. The catalytic converter **300** may include an external shell **302**, an inlet port **306**, an outlet port **308**, one or more filters **310**, and a plurality of spaces **312**. In this embodiment, electrical heating elements **314** may be arranged or disposed in the spaces **312**. The heating elements **314** may include heating wires constructed of, for example, nichrome wires, but are not limited thereto. Electrical leads **316** may extend from a power supply (not shown in the figure for clarify of illustration and description) to supply electrical energy to the heating elements **314**.

In one embodiment, the disruptor plates **318** may be placed at or near the inlet port **306** and the outlet port **308**. The disruptor plates **318** may be included to add or increase agitation to the flow of exhaust gases traversing across the filter **310**. As shown in FIG. **3**, the disruptor plates **318** may be oriented or disposed orthogonal to a longitudinal (or horizontal) axis **304** of the external shell **302**. Similar to the filter **110** shown in FIG. **1**, the filter **310** may be coated with one or more catalytic materials to maximize or increase contact with the toxic gases and particulates and to slow down the flow of the gases within and traversing through the catalytic converter **300**. Additionally, the heating elements **314** may further aid in the removal or reduction of harmful gases and particulate matters by heating the inside and the components (e.g., filters **310**) of the catalytic converter **300**. FIGS. **4**A and **4**B show an end view of the disrupter plate **318** that may include an array of holes **420** that may extend across in the direction of the flow of exhaust gases and particulate matters. The array of holes **420** may be scattered about the disrupter plate **318** in a uniform pattern as shown in FIG. **4**A or in a pseudorandom pattern as shown in FIG. **4**B. Further, the size and shape of the holes **420** may be varied in a suitable manner. FIG. **4**C shows one example of an end view of the filter **310**. Similar to the filter **110** in FIGS. **1** and **2**A, the filter **310** may include a plurality of holes **410** and a catalyst coating having a plurality of layers of ceramic and noble metals, similarly to the embodiments discussed above corresponding to FIGS. **2**A and **2**B.

FIG. **5** depicts a catalytic converter **500** according to an embodiment of the present disclosure. The catalytic converter **500** may include one or more filters **510**, heating elements **514**, electrical leads **516**, secondary planar heating elements **515**, **517**, disruptor plates **518**, and additional electrical leads **519**. The heating elements **514** may be arranged or disposed in a plurality of spaces **512**. The electrical leads **516** may extend from a power supply to supply power to the heating elements **514** and the secondary planar heating elements **515**, **517** that may be arranged near an inlet port **506** and/or an outlet port **508**, adjacent to the disruptor plates **518**. The additional electrical leads **519** may supply electrical energy to the secondary planar heating elements **515**, **517**. Although some of the various elements of the present disclosure are described as being planar or having particular orientations, it is not required that these geometrical restrictions be exact, and approximations thereto are within the description of the various embodiments of the present disclosure. Disruption of normal, substantially laminar flow of exhaust gases enhances the efficiency of the catalytic converter **500**. As such, the removal or reduction of the toxic gasses and particular matters exiting a catalytic converter is significantly improved by including the multiple heating elements **514**, **515**, **517** and disruptor plates **518**.

In one embodiment, the secondary planar heating elements **515**, **517** may be disposed or arranged adjacent or near one or more of the filters **510** instead of being disposed adjacent or near the inlet port **506** and/or outlet port **508**. The catalytic converter **500** removes or reduces the harmful gases and particulate matters as they pass through the catalytic converter **500**. The secondary planar heating elements **515**, **517** may be configured to heat the internal temperature of the catalytic converter **500** to, for example, about 800° C. to 1200° C., which aids in the removal or reduction of the harmful gases and particulate matters within or traversing through the catalytic converter **500**. The filter **510** (see FIG. **16** for illustration of an example filtering process) may be coated or sprayed with noble metals to aid in maintaining an internal temperature of, for example, about 800° C. to 1200° C. and in turn further aid in the removal or reduction of harmful gases and particulate matters. Additionally, similar to the embodiments described in accordance with FIGS. **1-4**, the catalytic converter **500** may include a catalyst coating such as shown in FIG. **2**B to aid in the removal or reduction of harmful gases and particulate matters.

FIG. **6** illustrates a catalytic converter **600** in accordance with an embodiment of the present disclosure. The catalytic converter **600** may include one or more filters **610** through which a magnetic field may be maintained between an inlet port **606** and an outlet port **608**. In this embodiment, the catalytic converter **600** is enhanced with an encompassing shell **602** partially or internally surrounding an external shell **603**. A plurality of magnets **607** may be located or arranged between the shells **602**, **603**. As shown in FIG. **7**, the plurality of magnets **607** may have a curved shape to approximate the outer geometry of the external shell **603** and may be provided in two sets **607***a*, **607***b*. The plurality of magnets **607** may be disposed in an array having alternating polarities as shown in FIG. **7**. In one embodiment, the magnets **607** facing each other may have opposing polarities. Alternatively, the magnets **607** may have the same polarity and the polarity may not vary along the longitudinal or horizontal direction of the catalytic converter **600**. Having magnets facing each other with opposite polarities results in a stronger magnetic field. In one embodiment, the plurality of magnets **607** may include one or more neodymium magnets. In another embodiment, the plurality of magnets **607** may be electromagnets. However, any suitable magnets may be used depending on the desired application. Similar to the embodiments disclosed in FIGS. **1-5**, heaters **612**, **613** may be arranged in one or more spaces within the catalytic converter **600**. Further, electrical leads **616**, **616** may be attached to a control unit and a power supply (not shown in the figure for clarity of illustration) that may be configured to switch between the heaters **612**, **613** to maintain a desired temperature, for example, by applying electric current between about 6 to 45 amps.

FIG. **8** shows a catalytic converter **800** in accordance with an embodiment of the present disclosure. In this embodiment, an array of magnets **807** may be placed to abut an external shell **802** from an inside surface of the external shell **802**. Similar to the embodiments described in accordance with FIGS. **1-7**, heating elements **814** may be arranged at or near the spaces **812** next to one or more filters **810** with electrical leads **816** that power the heating elements **814**.

FIG. **9**A shows an end view of the magnets **807** and FIG. **9**B depicts an exploded view of the magnets **807**. In one embodiment, a central core magnetic rod **809** may be provided as a part of the set of magnets **807**. The central core magnetic rod **809** may allow varying arrangements of polarities of the magnets **507**. For example, the magnets **807** that face each other may have the same or different polarities, which may vary along the longitudinal direction. In addition, the central core magnetic rod **809** may be one piece extending from the inlet port **806** to the outlet port **808**, with one polarity at each end. Alternatively, the central core magnetic rod **809** may be made of segments that may be separated from each other in the longitudinal direction and have polarities that may vary in the longitudinal direction. Although the magnets **807** have been depicted as fixed magnets, electromagnets may be provided in addition to or alternatively, to be operated with suitable current sources (not shown in the figure for clarity of illustration and description).

FIG. **10** illustrates a catalytic converter **1000** according to an embodiment of the present disclosure. The catalytic converter **1000** may include an external shell **1002**, an inlet port **1006**, an outlet port **1008**, one or more filters **1010**, a plurality of spaces **1012**, and a plurality of heating rods **1016**. In one embodiment, electrical heating elements **1014** may be arranged or disposed in the spaces **1012**. The heating elements **1014** may include heating wires constructed of, for example, nichrome wires, but are not limited thereto. Electrical leads **1018** may extend from a power supply to supply electrical energy to the heating elements **1014**.

FIG. **11**A shows an end view of the filter **1010** of FIG. **10**. In one embodiment, the filter **1010** may be, for example, a metallic or a ceramic filter including a plurality of honeycomb shaped openings **1110**. The openings **1110** may be configured to communicate gas and/or particulate matters from one end to the opposite end of the filter **1010**. The shape and size of the openings **1110** of the filter **1010** may vary depending on the desired application of the exhaust system of the present disclosure. In one embodiment, the size of the openings **1110** for the filter **1010** used in a gasoline engine system may be about 1/16 inch, but is not limited thereto. In another embodiment, the size of the openings **1110** for the filter **1010** used in a diesel engine system may be between about 1/8 inch to 1/4 inch, but is not limited thereto. Further, the plurality of rods **1016** may be inserted into the plurality of openings **1110**. The plurality of rods **1016** may extend from one end of the filter **1010** to the other end across the entire length of the filter **1010**. In some embodiments, the plurality of rods **1016** may extend partially through the filter **1010**, instead of extending across the entire length of the filter **1010**. The plurality of rods **1016** may facilitate rapid heating of the filter **1010** by quickly conducting the heat generated inside of the catalytic converter **1000** and transferring the heat to the filter **1010**. The number and location of the plurality of rods **1016** used in the filter **101** may be determined based on the amount or level of backpressure generated within the exhaust system using the catalytic converter **1000**. Accordingly, the number of plurality of rods **1016** may be determined at least on the shape and size of the filter, size of the openings **1110** of the filter **1010**, etc. Preferably, the level of backpressure measured with the plurality of rods **1016** inserted into the filter **1010** may be zero.

In one embodiment, the one or more filters **1010** may be coated with catalyst coating materials to maximize or increase contact between the filters **1010** and the toxic gases and particulate matters. The catalyst coating materials may slow down the flow of toxic gases and particulate matters that may traverse from the inlet port **1006** to the outlet port **1008**. Additionally, the catalyst coating materials may facilitate rapid heating of the catalytic converter **1000**. Embodiments of the catalyst coating and associated features thereof embodying the principles and concepts of the present disclosure are described hereinafter. The one or more filters **1010** may be coated with catalyst coating materials in the same manner as described above with respect to FIG. **2**B.

FIG. **11**B shows a perspective view of the filter **1010** of FIG. **10** including the plurality of rods **1016**. In one embodiment, the plurality of rods **1016** may be inserted into the plurality of openings **1110**. Further, the plurality of rods **1016** may extend from one end of the filter **1010** to the other end across the entire length of the filter **1010**. In some embodiments, the plurality of rods **1016** may extend partially through the filter **1010**, instead of extending across the entire length of the filter **1010**. As described above, the number and location of the plurality of rods **1016** may depend on the level of backpressure measured in the exhaust system utilizing the catalytic converter **1000**. By utilizing the plurality of rods **1016**, in addition to the catalyst coating **1120** described in accordance with FIG. **2**B above, the catalytic converter **1000** may be rapidly heated to dramatically improve the removal and reduction of the toxic or harmful gasses and particulates generated in a fossil fuel based internal combustion engine.

FIG. **12** illustrates a catalytic converter **1200** according to one exemplary embodiment of the present disclosure. In addition to the elements shown in FIG. **12**, the catalytic converter **1200** may include one or more features disclosed in accordance with the embodiments shown in FIGS. **1-11**. The catalytic converter **1200** may include a first housing (or shell) **1212**, a second housing (or shell) **1214** that may be encompassed by the first housing **1212**, an inlet **1216** where exhaust gases enter the first housing **1212** and an outlet **1218** where the exhaust gases exit the first housing **1212**. Within the internal cavity of the first housing **1212**, between the inlet **1216** and the outlet **1218**, a first filter **1226**, and a second filter **1228**. The first filter **1226** is configured to oxidize harmful exhaust gases and in particular carbon dioxide. The second filter **1228** may be configured to further reduce/eliminate harmful exhaust gases including, but not limited to, carbon dioxide, carbon monoxide, and nitrogen oxide, as well as hydrocarbons, and other harmful chemicals. The filters **1226**, **1228** may be formed of ceramic or metallic materials.

The first filter **1226** and the second filter **1228** may include, for example, ceramic filters including a plurality of honeycomb shaped openings that may be coated with a catalyst coating **1229** with one or more noble metals. The first filter **1226** and the second filter **1228** may include a plurality of heating rods **1230** that may extend through the honeycomb structure. A plurality of heating rods **1230** formed, for example, of a heat-treated metal or alloy (e.g., copper or steel), may extend longitudinally or horizontally across the filters **1226**, **1228** such that one end of each heating rod **1230** is orientated generally toward the inlet **1216** and the other end of each heating rod **1230** is orientated generally toward the outlet **1218** of the catalytic converter **1200**. Additionally or alternatively, the heating rods **1230** may be arranged to traverse about the filters **1226**, **1228**. In one embodiment, each heating rod **1230** in the first filter **1226** may extend from one end of the first filter **1226** to the other end of the first filter **1226** over the entire length of the first filter **1226**. Similarly, each heating rod **1230** in the second filter **1228** my extend from one end of the second filter **1228** to the other end of the second filter **1228** over the entire length of the second filter **1228**. Alternatively, one or more heating rods **1230** may partially extend across the first filter **1226** and/or the second filter **1228**. As addressed further below, the heating rods **1230** function to transfer heat into the filters **1226**, **1228** and the heated rod mass within the filters **1226**, **1228** facilitates maintaining a constant temperature effectively within the catalytic converter **1202**. Additionally, between the first housing **1212** and the second housing **1214**, a plurality of magnets **1232** may be arranged and disbursed. While the placement of the magnets **1232** is shown between the housings **1212**, **1214**, the magnets **1232** may be placed on or within both filters **1226**, **1228**, within the first cavity **1222** and/or external of the first housing **1212**. In one embodiments, the number of heating rods **1230** may be determined by the size of the filters **1226**, **1228**. For example, for a filter having a size of about 12×5 inch, about 6 to 8 rods may be provided. The number of the rods may be based on the backpressure of the exhaust system. In one embodiment, the size of the filter may be modified to reduce or eliminate the exhaust air flow backpressure.

To facilitate monitoring the amount of oxygen in the exhaust gas, an oxygen sensor **1220**, which communicates with an electronic control unit, may be disposed or fixed external or internal to the catalytic converter **1200**. The oxygen sensor **1220** is configured to measure the amount of oxygen (or the concentration of combustibles) in the exhaust gases leaving the engine. An exhaust system may have both upstream and downstream oxygen sensors **1220**. Upstream oxygen sensors **1220** are located before the catalytic converter **1200**, while downstream sensors are located after the catalytic converter **1200**. The engine computer, which is often referred to as the powertrain control module (PCM), may use data from the upstream oxygen sensor **1220** to regulate the engine's fuel mixture. Meanwhile, the PCM may use the signal from the downstream oxygen sensor **1220** for monitoring the health of the catalytic converter **1200**.

The oxygen sensor **1220** may extend into a first cavity **1222** of the first housing **1212**, downstream of the inlet **1216** and before the first filter **1226**. To increase the internal temperature of the catalytic converter **1202** above a threshold temperature, an electric heater **1224** extending into the first cavity **1222** from outside of the second housing **1214**, may be disposed upstream of the first filter **1226**. The heater **1224** may be connected to a power source and an electronic control unit that may be arranged external to the catalytic converter **1202** and may be configured to heat the interior of the catalytic converter **1200** above a threshold temperature. The power source and the electronic control unit may control the heater **1224** based on temperature sensor data provided by a temperature sensor **1245** that may be arranged near the outlet **1218**. The heater **1224** depicted in FIG. **12** may include a wound metal coil **1225**. However, the heater **1224** may take any form (further described later in detail below) to ensure rapid internal heating of the catalytic converter **1200**. While the heater **1224** is shown to extend into the catalytic converter **1200** in FIG. **12** before the filters **1226**, **1228** more than one heater **1224** may be arranged to extend into the catalytic converter **1200**. For example, the heater(s) **1224** may be arranged within one or more of the filters **1226**, **1228**, or within the first cavity **1222** and/or a second cavity **1223**, between the filters **1226**, **1228**, etc. As such, the placement of the heater(s) **1224** is not limited to the embodiment shown in the figures of the present disclosure. Further, one or more heaters with varying designs in accordance with the present disclosure may be arranged entirely within the cavities **1222**, **1223** of the catalytic converter **1200** at any position within the first housing **1212** and/or the second housing **1214** and/or may be fixed external to the catalytic converter **1200** and/or fixed within or external to the tubing **1206** that is located directly upstream of the catalytic converter **1200**.

FIG. **13** illustrates an exemplary catalytic converter **1300** according to an embodiment of the present disclosure. The catalytic converter **1300** may include a first heater **1315** in front of a filter **1325**, and a second heater **1317** behind the filter **1325**. Additionally, temperature sensors **1326**, **1327** may be placed adjacent or near the first and second heaters **1315** and **1317** to monitor the internal temperature of the of the catalytic converter **1300** and to ensure that proper internal temperature is maintained. As shown in FIG. **13**, various gases may enter and catalytic converter **1300** to be reduced or removed by the catalytic converter **1300** according to embodiments of the present disclosure.

FIG. **14** shows a selective catalytic reduction system (SCR) **1400** in accordance with an embodiment of the present disclosure. In one embodiment, the SCR **1400** may be arranged downstream of a catalytic converter or other exhaust converters (e.g., oxidation catalyst and/or a diesel particulate filter) in accordance with embodiments of the present disclosure. The SCR **1400** may be coupled downstream to a catalytic converter (or other exhaust converter) by a tubing **1606** (shown in FIG. **16**). The SCR **1400** is configured to reduce nitrogen oxide (NO_x) gases by oxidizing the nitrogen oxide gases and converting them into harmless exhaust emissions (e.g., nitrogen, water, and a small amount of carbon dioxide) that are emitted out of the exhaust system of the present disclosure and into the environment. In one embodiment, the SCR **1400** reduces the exhaust emissions without the need to incorporate a liquid-reductant agent into the exhaust stream to reduce the amount of nitrogen oxide. In other embodiments, SCR **1400** may include one or more injectors to inject a liquid reductant agent (e.g., urea) to facilitate the reduction or removal of harmful exhaust emissions. One source of urea is AdBlue, which comprises about 32.5% high quality urea dissolved in distilled water.

As illustrated in FIG. **14**, the SCR **1400** may include a filter **1440**, a plurality of heating rods **1446**, and a heating element **1424**. The heating element **1424** depicted in FIG. **14** may include a wound metal coil **1425**. However, the heating element **1424** may take any form (further described later in detail below) to ensure internal heating of the SCR **1400**. Further, as shown in FIG. **15**A, the filter **1440** may include a plurality of honeycomb shaped openings **1547**. The specific shape and size of the openings **1547** is not limited thereto, and any suitable shape and size may be used according to the desired application of the SCR **1400**. In one embodiment, the plurality of heating rods **1446** may be inserted into the honeycomb shaped openings **1547**. FIG. **15**B shows a partial perspective view of the filter **1440**. In addition to the honeycomb shaped openings **1547**, the filter **1440** may include a plurality of holes **1542** that may be dispersed about the filter **1440**. The plurality of holes **1542** may be included to further disrupt the flow of exhaust gases from a laminar path and to slow down the gases from exiting the SCR **1400**. The filter **1440**, similar to the filters disclosed in the embodiments of FIGS. **1-13**, may be coated with a catalyst coating **1548** in the same manner as described above with respect to FIG. **2**B.

In one embodiment, the heating rods **1446** may extend longitudinally through the honeycomb structure such that the one end of each heating rod **1446** may be orientated generally toward an inlet of the SCR **1400** and the other end of each heating rod **1446** may be orientated generally toward an outlet of the SCR **1400**. The heating rods **1446** may include a heat-treated metal or alloy (e.g., copper or steel). The heating element **1424** may communicates with an electronic control unit, and may extend into the SCR **1400** upstream of filter **1440**. Similar to the filters of the foregoing embodiments disclosed in FIGS. **1-13**, the heating rods **1446** and the catalyst coating **1548** of the filter **1440** of the SCR **1400** facilitate rapid heating and ensure that the internal temperature across the filter **1440** is sufficiently maintained. Additionally or alternatively, the SCR **1400** may include one or more nitrogen oxide or O_2 sensors that may be monitored and controlled by the electronic control unit for controlling the heating element **1424**.

By increasing the internal temperature of the SCR **1400**, additional harmful chemicals and particulates of the exhaust gas are burned off. The filter **1440** facilitates to trap and/or slow the flow of the exhaust gases passing across the internal cavity of the SCR **1400** through the honeycomb shaped openings **1547**. The catalyst coating **1548** facilitates to further slow and disrupt the flow of the exhaust gases such that additional harmful exhaust emissions may be heated above a threshold temperature (that exceeds a normal operating temperature within the SCR **1400** absent the heating element **1424**) and burn off prior to exiting the SCR **1400**. In addition to the heating rods **1446** and the catalyst coating **1548**, a plurality of magnets (not shown in the figures for clarity of illustration) may be arranged and disbursed internal or external to the SCR **1400** similar to the foregoing embodiment of FIGS. **6-9**B.

Similar to the magnets **1232** in the catalytic converter **1200**, the polarity of the magnets may further disrupt and slow the flow **1550** of exhaust gases and particulates as they pass over the filter **1440** by increasing the electric current in the vicinity of the magnets to disrupt and to slow the flow of exhaust gases and particulates which in turn allows for heating of the exhaust gases for a longer period of time within the SCR **1400** and in turn further oxidization and reduction of toxic byproducts of exhaust gases. Additionally or alternatively, the magnets may be arranged between the filter **1440** and the selective catalytic reduction system **1400**, and/or external the selective catalytic reduction system **1400** housing. Because the temperature within the SCR **1400** may become very high, the magnets may be capable of operating at the expected maximum temperature without suffering degradation (e.g., AlNiCo magnets).

FIG. **16** shows an exhaust system **1600** according to an embodiment of the present disclosure. In one embodiment, the exhaust system **1600** may be configured or designed for an internal combustion engine that utilizes gasoline. The exhaust system **1600** may include a catalytic converter **1602**, a selective catalytic reduction system (SCR) **1604**, one or more electric heaters **1624**, one or more heat sensors **1630**, one or more gas (or oxygen or O_2) sensors **1655**, and a muffler **1608**. The catalytic converter **1602** may be coupled to the SCR **1604** via a first tubing **1606**, and the SCR **1604** may be coupled to the muffler **1608** via a second tubing **1610**, as shown in FIG. **16**. The heat sensor **1630** may be configured to detect the temperature of the exhaust gas prior to exiting the catalytic converter **1602**. The heat sensor **1630**, which may be connected to an electronic control unit (ECU), may be located near the inlet **1616** and/or outlet **1618** of the catalytic converter **1602**.

In one exemplary embodiment, upon startup of an engine from a cold start, one or more electric heaters **1624** may be simultaneously turned on by the electronic control unit to aid in heating the internal temperature of the catalytic converter **1602** above the temperature of the exhaust gases and particulate matter. The one or more electric heaters **1624** may remain on after reaching a desired temperature or may be turned off and then turned back on if the temperature within the catalytic converter **1602** drops below a predetermined threshold temperature. The electronic control unit which may receive input signals from one or more thermometers and other sensors and may generate a signal to control the activity of the one or more electric heaters **1624**. A plurality of rods (not shown in the figures for clarity of illustration) may extend longitudinally or horizontally within the filters **1626**, **1628** in an assembled state within the catalytic converter **1602**. The rods may provide a conduit for more rapid heat transfer from the one or more electric heaters **1624** through the filters **1626**, **1628**, and thereby accelerate heating the internal temperature of the catalytic converter **1602** to a desired internal temperature and aid in maintaining the desired internal temperature above a threshold across the surface area of the filters **1626**, **1628**, and a cavity **1622** of the catalytic converter **1602** to oxidize harmful exhaust gases at least throughout the filters **1626**, **1528** and surrounding internal surface areas.

By increasing the internal temperature of the catalytic converter **1602** to a temperature greater than the normal operating temperature of the catalytic converter **1602**, harmful chemicals and particulates that are part of the exhaust gas are oxidized and/or burned off before exiting the catalytic converter **1602** more efficiently than in a conventional catalytic converter. The filters **1626**, **1628** facilitate to trap and/or slows the flow of the exhaust gases as they passes across the internal cavity of the catalytic converter **1602** through the honeycomb openings, and the noble metal filter coating (not shown in the figure for clarity of illustration and description) aids to further slow and disrupts the flow of the exhaust gases across the cavity **1622** such that more of the harmful exhaust emissions can be heated above a threshold exhaust gas temperature and oxidize and/or burn off prior to exiting the catalytic converter **1602**. The threshold temperature may be optimized for any given configuration based on the amount of additional oxidization/burn off desired based on the exhaust system **1600** components and other factors.

In one embodiment, the polarities of magnets **1632** aid to further disrupt and slow the flow of exhaust gases and particulates as they pass through the catalytic converter **1602** by increasing the electric current within the cavity **1622** of the catalytic converter **1602**. Disrupting and slowing the flow of exhaust gases and particulates allows for heating of the exhaust gases for a longer period of time within the cavity **1622** of the catalytic converter **1602** and in turn further oxidization and reduction of toxic byproducts of exhaust gases. Because the temperature within the catalytic converter **1602** may be very high, the magnets **1632** may be configured to operate at the expected maximum temperature without suffering degradation (e.g., AlNiCo magnets, neodymium magnets, etc.).

Similar to the SCR **1400** described according to FIGS. **14-15**B, the SCR **1604** may be configured to reduce nitrogen oxide (NO_x) gases by oxidizing the nitrogen oxide gases and converting them into harmless exhaust emissions (e.g., nitrogen, water, and a small amount of carbon dioxide) by rapidly heating the SCR **1604** through a plurality of rods and a catalyst coating according to the foregoing embodiments of FIGS. **1-15**B. Upon exiting the SCR **1604**, the remaining exhaust gases may flow through the tubing **1610** that connects the SCR **1604** and into the muffler **1608**. The muffler **1608** may be configured to reduce or “muffle” engine noise, and may further reduce remaining harmful exhaust gases and cool the exhaust temperature.

FIG. **17** illustrates an exhaust converter **1700** in accordance with an embodiment of the present disclosure. The exhaust converter **1700** may be utilized in a gasoline or a diesel based engine system. Further, the exhaust converter **1700** may be designed or configured to be used as, for example, a catalytic converter, an SCR, oxidation catalyst, a diesel particulate filter (DPF).

In one embodiment, the exhaust converter **1700** may include a first heater **1720**, a first filter **1721**, a second heater **1726**, and a second filter **1728**. The first heater **1720** may receive power from a power supply (not shown for clarity of illustration and description) via a first connector **1724**, and the second heater **1726** may receive power from the power supply via a second connector **1734**. The first heater **1720** and the first filter **1721** may be an integrated unitary device. Alternatively, the first heater **1720** and the first filter **1721** may be separate devices that may be combined or attached together via any suitable securing means (e.g., via welding, screws, bolts, etc.). Similarly, the second heater **1726** and the second filter **1728** may be an integrated unitary device. Alternatively, the second heater **1726** and the second filter **1728** may be separate devices that may be combined or attached together via any suitable securing means (e.g., via welding, screws, bolts, etc.). The first heater **1720** and the second heater **1726** may be different types of heaters, as shown in FIG. **17**. Alternatively, the first heater **1720** and the second heater **1726** may be the same type of heaters.

In one embodiment, the first heater **1720** may include a heating element **1722**. The heating element **1722** may be made of, for example, a metallic material, and the heating element **1722** may include a plurality of openings (e.g., honeycomb shaped openings). Additionally, the first heater **1720** may include a plurality of heating rods **1716** extending across the first heater **1720** in a horizontal direction. The heating rods **1716** may fully extend horizontally from one end to the other end of the first heater **1720**. Alternatively, the heating rods **1716** may partially extend horizontally within the first heater **1720**. Further, the heating rods **1716** may be inserted into the plurality of openings of the heating element **1722**. In one embodiment, the heating rods **1716** may include, for example, a heat-treated metal or alloy (e.g., copper or steel)

In one embodiment, the first heater **1720** may be heated by applying electric potential between the first connector **1724** and a housing **1723** (e.g., a metal housing) of the first heater **1722**. The first connector **1724** and the housing **1723** may be configured to function as a first and second terminals (e.g., positive and negative (or ground) terminals). The heating element **1722** and the housing **1723** may be electrically coupled to a power supply. As such, the first heater **1720** may rapidly heat up when an electric potential is applied by the power supply to induce current to pass through the first heater **1720**. Accordingly, the housing **1723**, the heating element **1722**, and the heating rods **1716** may facilitate rapid heating of the first heater **1720**. For example, the heating rods **1716** facilitates transferring the heat generated inside of the first heater **1720** to the heating element **1722**. The heating element **1722** may function as a filter that may aid in the removal and reduction of the exhaust gases and particulate matters. The first filter **1721** may be made of a ceramic or a metallic material depending on the desired application of the exhaust converter **1700**. Similar to the catalytic converters and the SCRs described in accordance with the foregoing embodiments of FIGS. **1-16** above, the first filter **1721** may include a plurality of heating rods (not shown in the figure for the clarity of illustration) and a thin catalyst coating. Accordingly, the heat generated from the first heater **1720**, the thin catalyst coating, and the plurality of heating rods may facilitate rapid heating the first filter **1721**.

In one embodiment, the second heater **1726** may include one or more heating wires **1727**. As shown in FIG. **17**, the heating wires **1727** may be arranged in a web pattern. However, any suitable shape and/or size of the heating wires **1727** may be utilized. The heating wires **1727** may be coupled to the second connector **1734**. In this embodiment, the second heater **1726** may be heated by applying electric current to the heating wires **1727**. The power supply may be configured to provide electric current to the first and second connectors **1724** and **1734** simultaneously or sequentially. The heat generated by the heating wires **1727** may heat the second filter **1728**. The second filter **1728** may include a plurality of heating rods **1730**. In some embodiments, the heating wires **1727** may be attached to the heating rods **1730** to prevent potential damage to the heating wires **1727** that may be caused by vibrations or other internal or external movements or forces. The second filter **1728** may be made of a ceramic or a metallic material depending on the desired application of the exhaust converter **1700**. Similar to the catalytic converters and the SCRs described in accordance with the foregoing embodiments of FIGS. **1-16** above, the second filter **1728** may include a thin catalyst coating. Accordingly, the heat generated from the second heater **1726**, the thin catalyst coating, and the plurality of heating rods **1730** may facilitate rapidly heating of the second filter **1728**. In some embodiments, the first filter **1721** and/or the second filter **1728** made of metallic materials may be electrically coupled to one or more terminals of the power supply to further aid in rapid heating of the first filter **1721** and/or second filter **1728**. Further, the locations of the first heater **1720** and the second heater **1726** are not limited as shown in FIG. **17**. The locations of the first and second heaters **1720**, **1726** may be suitably determined based on the desired application of the exhaust converter **1700**.

It is understood that the first heater **1720** may include both a heating element **1722** and one or more heating wires such as heating wires **1727** (see, e.g., FIG. **19**). Likewise, the second heater **1726** may include one or more heating wires **1727** and a heating element and such as heating element **1722** (see, e.g., FIG. **19**). As noted, the heating element **1722** may function as a filter that may aid in the removal and reduction of the exhaust gases and particulate matters.

FIGS. **18**A-**23**B show various exemplary heaters and components that may be incorporated into any of the foregoing embodiments disclosed in FIGS. **1-17**. FIG. **18**A illustrates a perspective view of a heater **1800** according to an embodiment of the present disclosure. The heater **1800** may include a housing (or a chassis) **1802**, one or more heating wires **1804**, and a connector **1806**. In one embodiment, the heating wires **1804** may be coupled to the housing **1802** and the connector **1806**. For example, one end of a heating wire **1804** may be coupled to the housing **1802** and the other end of the heating wire **1804** may be coupled to the connector **1806**. As shown in FIG. **18**A, the connector **1806** may include one or more terminals configured to receive electric current from a power supply and one or more ceramic portions **1808** that function as electrical insulators to provide electrical insulation between the surface of the housing **1802** and the connector **1806**. The one or more terminals may be, for example, a positive (or negative) terminal of the connector **1806**. The housing **1802** may be configured as a negative (or positive) terminal or ground.

In one embodiment, the heating wires **1804** may include a spiral (or zig-zag) shape, as shown in FIG. **18**A. However, the heating wires **1804** may have any suitable shape depending on the desired application of the heater **1800**. The heating wires **1804** may be made of a chrome-nickel resistance material having a thickness of about 1.2 mm. The thickness and length of each of the heating wires **1804** may be determined based on the amount (or level) of current applied to the heating wires **1804**. For example, a length of about 40 cm may be used for an electric current supply of about 48 to 60 amperes. For about 30 amperes of current supply, a length of about 20 cm may be used. In some embodiments, a plurality of heating wires **1804** may be used by connecting, for example, an end of each of the plurality of heating wires **1804** to each of a plurality of positive terminals of the connector **1806**, while connecting all of the other ends of the plurality of heating wires together to a single negative terminal on the surface of the housing **1802**. Accordingly, the supply current may be divided into the plurality heating wires **1804**, thereby reducing the total amount of current supplied by the number of heating wires **1804**. The thickness and length of each of the plurality of heating wires **1804** may be calculated relative to the level of the current supplied to the heating wires **1804**. Utilizing a plurality of heating wires **1804** may allow each of the heating wires **1804** to be shorter and thinner. Thus, the heating wires **1804** may heat up substantially quicker than a single heating wire having a larger thickness and length.

FIG. **18**B shows a perspective view of a heater **1810** according to another embodiment of the present disclosure. The heater **1810** may include heating wires **1814** having a web shape (not limited thereto), a housing (or chassis) **1821**, and a plurality of rods **1818** configured to hold the heating wires **1814** in place. The heating wires **1814** may heat up when current is supplied by a power supply via the connector **1816**. The connector may include a positive terminal and a negative terminal. In some embodiments, the housing **1812** may be configured as a negative terminal or a ground. Similar to the heating wires **1804** disclosed according to the embodiment of FIG. **18**A described above, the shape, thickness, and length of the heating wires **1814** may be determined in relation to the level of current supplied from the power supply. The heater **1810** may be arranged, for example, about 1 to 1.5 inches in front of a ceramic honeycomb filter.

FIG. **18**C illustrates a detailed view of heaters **1830** according to another embodiment of the present disclosure. As shown in FIG. **18**C, the heaters **1830** may be designed to include different sizes and patterns. The heaters **1830** may be made of metallic materials configured to heat up rapidly when electric current is applied to the heaters **1830**. The heaters **1830** may be used additionally or alternatively to any of the heaters disclosed in the embodiments of FIGS. **1-18**B.

FIG. **19** illustrates a heater **1900** according to an embodiment of the present disclosure. The heater **1900** may include a housing **1902**, a first terminal **1903**, a second terminal **1904**, one or more heating wires **1906** (although only one is shown, multiple levels of the heating wires, similar to the heating wires **1804** shown in FIG. **18**A, may be utilized), a heating element **1908**, a plurality of heating rods **1910**, and a connector **1912**. The housing **1902** may be a metallic housing.

The first terminal **1903** may be a positive (or negative) terminal, and the second terminal **1904** may be a negative (or positive) terminal or ground. In one embodiment, the first terminal **1903** may be electrically coupled to the connector **1912**, and the second terminal **1904** may be electrically coupled to the housing **1902**.

The heating wire **1906** may be electrically coupled between the first terminal **1903** and the second terminal **1904**. In this embodiment, the connector **1912** may be configured to receive electric current from a power supply and may function as a positive (or negative) terminal. Further, the housing **1902** may be configured to function as a negative (or positive) terminal or ground. Accordingly, an electrical potential supplied by the power supply between the positive terminal **1903** (e.g., via the connector **1912**) and the negative terminal **1904** (e.g., via the housing **1902**) may induce electric current between the first terminal **1903** and the second terminal **1904**. Accordingly, the heating wire **1906** coupled between the first terminal **1903** and the second terminal **1904** may heat up based on the level of supplied current. Additionally, the heating element **1908**, which may include a metallic material, may be electrically coupled to the first and/or second terminals **1903**, **1904**, and may also heat up as a result of the current being supplied.

Heating rods **1910** may further facilitate heating up the heating element **1908** by rapidly conducting heat that may be generated by the heating wire **1906**. In one embodiment, the heating rods **1910** may be inserted into the openings of the heating element **1908** and may extend from one end of the heating element **1908** to the other end of the heating element **1908**. The heating rods **1910** may also include rods that may partially extend from one end of the heating element **1908** to the other end of the heating element **1908**. Further, the heating rods **1910** may act as supports configured to hold the heating wire **1906** in place. In this example, the heating rods **1910** partially extend from one end of the heating element **1908** to the other end of the heating element **1908**.

In one embodiment, the heating wire **1906** may include a spiral shape, as shown in FIG. **19**. However, specific shape and size of the heating wire **1906** may not be limited thereto, and may have any suitable shape or size depending on the desired application of the heater **1900**. Similar to the heating wires **1804**, the heating wire **1906** may be made of a chrome-nickel resistance material having, preferably, a thickness of about 1.2 mm. The length of the heating wire **1906** may be determined based on the amount (or level) of current applied to the heating wire **1906**. For example, a length of about 40 cm may be used for an electric current supply of 48 amperes. For 30 amperes of current supplied, a length of about 20 cm may be used. As such, the length and thickness of the heating wire **1906** may be calculated relative to the level of the current supply. In some embodiments, a plurality of heating wires **1906** may be utilized similar to heating wires **1804**.

In one embodiment, heating element **1908** may act as a filter and may include a catalyst coating in accordance with the foregoing embodiments of FIGS. **1-18**C. The catalyst coating may further facilitate rapid heating of the heater **1900**. Additionally or alternatively, one or more magnets in accordance with the embodiments of FIGS. **6-9**B may be placed or arranged in a cavity (or space) **1914** between the housing **1902** and the first and second terminals **1903**, **1904** to facilitate rapid heating of the heater **1900**. As such, the heater **1900** may be rapidly heated by via one or more combinations of at least the heating wires **1906**, heating rods **1910**, a catalyst coating, and/or magnets in accordance with the embodiments of FIG. **19**.

FIG. **20** illustrates a perspective view of the heater **2000** according to an embodiment of the present disclosure. Similar to the heater **1900** of FIG. **19**, the heater **2000** may include a housing **2002**, a first terminal **2004**, a second terminal **2006**, a heating element **2008**, a plurality of heating rods **2016**, and one or more heating wires (not show for clarity of illustration and description). The heater **2000** may function similarly to the heater **1900** disclosed in the foregoing embodiments of FIG. **19**. In one embodiment, the plurality of heating rods **2016** may be inserted into the openings of the heating element **2008**. The plurality of heating rods **2016** may include a metallic material, and the plurality of heating rods **2016** may secure the heating wires (e.g., heating wires, **1804**, **1814**, and/or **1906**).

FIG. **21** illustrates one exemplary heating rod **2016** according to an embodiment of the present disclosure. The heating rod **2016** may include a rod portion **2106** made of metal (e.g., a heat-treated metal or alloy (e.g., copper or steel)) and a tip portion **2104** made of an aluminum alloy having an insulative property. Accordingly, the tip portion **2104** may prevent passage of current through the heating rod **2016**, so as to prevent any shorting or overheating of the heating rod **2016**.

Further, the heating rod **2016** may include a clip **2102** (e.g., fastener) configured to secure the heating wires in place. In one embodiment, a heating wire may be snapped into an opening **2103** of the clip **2102**. The opening **2013** may have any suitable shape similar to the heating wire, so as to secure the heating wire in the clip **2102**. The clip **2102** may be an electrical insulator configured to prevent passage of current through the corresponding heating rod **2016**. Accordingly, one or more of the plurality of heating rods **2016** may hold the heating wires of the present disclosure securely in place during operation of a machine or vehicle including the exhaust system of the present disclosure.

In one embodiment, the heating rods **2016** may be spaced, for example, about 2 inches from each other. The spacing of the heating rods **2016** is not limited thereto, but may be spaced apart from each other based on the desired application (e.g., the shape and length of the heating wire) of the present disclosure. Further, the plurality of heating rods **2016** may additionally facilitate rapid heating of the heating element **2008** by conducting heat generated inside of the heater **2000** by the rod portions **2106** of the plurality of heating rods **2016**. In one embodiment, the plurality of heating rods **2016** may be inserted directly into a filter of an SCR instead of a heating element as shown in FIG. **20**. Thus, the heating rods **2016** may facilitate, for example, via thermal conduction, the additional rapid heating introduced by the inclusion of heating wires **1906** (not shown in FIGS. **20** and **21**) but are electrically isolated from said heating wires **1906**.

One or more of the heating rods **2016** may extend through the heating element **2008** to further facilitate rapid heating of the heater **2000**. In one embodiment, the plurality of heating rods **2016** may have varying lengths. For example, some heating rods **2016** may be longer than other heating rods **2016**. That is, the longer heating rods **2016** may be configured to secure heating wire **1906** at one displacement, and the shorter heating rods **2016** may be configured to secure heating wires at another displacement. For example, as shown in FIG. **18**A, the longer heating rods **2016** may secure the heating wires **1804** disposed at a top layer portion (displacement), and the shorter heating rods **2016** may secure the heating wires **1804** at a bottom layer portion (displacement).

FIG. **22** depicts an exemplary embodiment of an exhaust converter (e.g., a catalytic converter, SCR, oxidation catalyst, DPF, etc.) **2200** of the present disclosure. The exhaust converter **2200** may include a plurality of heaters **2215**, **2216**, **2217**, **2218**, **2220** having various types, shapes and sizes that may be placed or arranged at various locations within the exhaust converter **2200**. In embodiments of the present disclosure, any suitable number of heaters may be utilized based on the desired application in accordance with the present disclosure.

FIGS. **23** and **24** depict one type of a heater **2300** according to an embodiment of the present disclosure. The heater **2300** may be inserted into an exhaust converter (e.g., a catalytic converter, SCR, oxidation catalyst, DPF, etc.) of the foregoing embodiments of the present disclosure from the outside thereof and may be screwed in place. As such, the heater **2300** may be removably attached to the exhaust converter of the present disclosure. The heater **2300** may also be inserted into the tubes of the exhaust system. More specifically, such heater may be provided as an aftermarket part and installed in an exhaust tube of an existing vehicle without having to modify the catalytic converter, SCR or DPF components. The same or similar type of heater **4100** is also shown in FIG. **41**. The heater **2300/4100** may be formed of a heating wire **2304/4104** helically wrapped around a support stud/rod **2308/4108**. The support stud/rod **2308/4108** may be connect to a positive or negative terminal; in one embodiment the support stud/rod **2308/4108** is connected to a negative terminal and may be connected to the housing in which the heater is inserted. The heater **2300/4100** may include a connector stud **2310/4110** which may be connect to a positive or negative terminal; in one embodiment the connector stud **2310/4110** is connected to a positive terminal and configured to be accessible external to the exhaust converter or exhaust tube. FIG. **41** illustrates the external power source connectors **4120** and **4130** which are connected to the heater **4100**. In one embodiment, **4120** is a positive power supply cable and **4130** is a negative power supply cable. In another embodiment, **4120** is a negative power supply cable and **4130** is a positive power supply cable. The power source cables **4120** and **4130** may be connected in a variety of ways know to a person of ordinary skill in the art; in GIF. **41** they are illustrated as electrical lugs which are screwed/bolted to the associated terminal.

FIGS. **25** and **26** shows a muffler **2500** according to an embodiment of the present disclosure. In one embodiment, the muffler **2500** may be utilized in the exhaust system **1600** of FIG. **16** that may be configured or designed for an internal combustion engine that may be configured to operate on gasoline or diesel. The muffler **2500** may include a housing **2510** in which one or more silencers **2508** and a plurality of plates **2506** that are interspersed and/or spaced from each other may be located. The plates **2506** may be formed of, for example, steel, and may be coated with one or more noble metal(s) **2602** (such as described above in FIG. **2**B). The noble metal coating **2602** may disrupt the flow of the exhaust gases within the housing **2510** such that they become turbulent, which in turn slows the flow of the hot exhaust gases as they pass from an inlet **2502** of the muffler **2500** through and exit the housing **2510** though an outlet **2504**. The disruption of the exhaust gases within the muffler **2500** due to the plates **2506** coated with one or more noble metals **2602** allows the exhaust gases and particulate matters more time within the muffler **2500** to burn off and/or oxidize prior to exiting the muffler **2500** and entering the environment. In addition, the plurality of plates **2506** inside the inlet **2502** may recirculates the exhaust air in and out, and may cut down NOx, for example, about 15%.

FIG. **27** shows an exemplary exhaust system **2700** according to an embodiment of the present disclosure. The exhaust system **2700** may include a catalytic converter **2702** and a control unit **2721** electrically coupled to the catalytic converter **2702**. The catalytic converter **2702** may include components similar to the components of the foregoing catalytic converters described according to the embodiments of FIG. **1-26**. The control unit **2709** may be electrically coupled to the catalytic converter **2702** via one or more electrical leads (or cables) **2706** to facilitate the operation of the exhaust system **2700** by controlling one or more of the heating elements **2717** based on readings from the one or more sensors. In this embodiment, the catalytic converter **2702** may include a plurality of magnets **2707** and a heating element **2717** to facilitate rapid heating of the catalytic converter **2702**.

FIG. **28** shows an exhaust system **2800** according to an embodiment of the present disclosure. The exhaust system **2800** may include a controller **2802** coupled to an exhaust converter system **2807**. The exhaust converter system **2807** may be coupled to an engine **2804** that may generate harmful gases and particulate matters, for example, due to an internal combustion of fossil fuel by the engine **2804**. The controller **2802** may be electrically coupled to the engine **2804** and the exhaust converter system **2807**. The controller **2802** may be configured to receive various signals and/or data from the engine **2804** and the exhaust converter system **2807** to facilitate controlling of the engine **2804** and the exhaust converter system **2807** to sufficiently operate a vehicle or a machine.

In one embodiment, the exhaust converter system **2807** may include an intake chamber **2816** coupled to the engine **2804** to communicate exhaust gases from the engine **2804** to a catalytic converter **2818**. The catalytic converter **2818** may include one or more heaters **2820** and other components associated with a catalytic converter as described above in accordance with the foregoing embodiments of FIGS. **1-27**. The exhaust converter system **2807** may further include an intake/exhaust chamber **2822** to communicate filtered (or converted) and/or reduced gases down to a selective reduction catalyst filtering system (SCR) **2824**. The SCR **2824** may include one or more heaters **2826** and other components associated with the foregoing SCR according to the embodiments of FIGS. **1-27**. Further, the exhaust converter system **2807** may include an exhaust chamber **2848** that may be coupled to a muffler (not shown for clarity of illustration and description).

In one embodiment, the exhaust converter system **2807** may include gas sensors **2850**, **2854**, **2856**. For example, the gas sensor **2850** may be coupled to the intake chamber **2816**, the gas sensor **2854** may be couple to the intake/exhaust chamber **2822**, and the gas sensor **2856** may be coupled to the exhaust chamber **2848**. The gas sensors **2850**, **2854**, **2856** may include, for example, an oxygen (e.g., O_2) sensor, but are not limited thereto and any suitable gas sensor may be utilized based on the desired application of the exhaust system **2800**. Additionally, the exhaust converter system **2807** may include temperature sensors **2852**, **2853**, **2855**, **2858**, and dosing injectors **2810**, **2812** coupled to solution tank **2806**, **2808** for injecting or pumping a dosing solution, such as a urea, salt water, or ammonia solution, among other possible solutions, to the exhaust flow gas. The gas sensor **2850** may be arranged before the catalytic converter **2818**, and the gas sensor **2854** may be arranged between the catalytic converter **2818** and the SCR **2824**.

The controller **2802** may receive signals from the temperature sensor **2852** to controls the heater **2818**. Further, the controller **2802** may receive signals from the temperature sensor **2853** to control the dosing injector **2810**. For example, when a predetermined temperature in the catalytic converter **2818** is detected by the temperature sensor **2853**, the controller **2802** may send command signals to the dosing injector **2810** to inject or shoot dosing solution into the catalytic converter **2818**. In one embodiment, the dosing injector **2810** may continuously inject dosing solution supplied by the solution tank **2806** into the catalytic converter **2818** at a predetermined interval if the temperature sensor **2853** detects that a predetermined temperature is maintained. Alternatively, the temperature sensor **2853** may be configured to detect a predetermined temperature range, for example, about 340 to 410 degrees Celsius. In other words, the dosing solution injected into the catalytic converter **2818** at the predetermined temperature or the predetermined temperature range may improve reduction or removal of harmful gases (e.g., NOx, etc.) in the catalytic converter **2818**.

In one embodiment, the gas sensor **2850** may detect the condition or state of the exhaust gas in the intake chamber **2816**, and the gas sensor **2854** may detect the condition or state of the exhaust gas in the intake/exhaust chamber **2822**. That is, the gas sensors **2850**, **2854** may transmit data related to the condition or state of the exhaust gas to the controller **2802**. Accordingly, the controller **2802** may utilize the received gas data to monitor the effectiveness of the catalytic converter **2818** and to perform appropriate functions to achieve desirable performance of the catalytic converter **2818**. Further, the controller **2802** may utilize the received gas data and display the gas monitoring information on one or more displays coupled to the exhaust system **2800**. In one embodiment, the controller **2802** may automatically control the engine **2804** and/or the exhaust converter system **2807** to achieve desired performance and and/or functionality of the exhaust system **2800**. In another embodiment, an operator of the exhaust system **2800** may manually control the engine **2804** and/or the exhaust converter system **2807** to achieve desired performance and/or functionality of the exhaust system **2800** based on the gas and/or temperature monitoring data displayed on the display coupled to the exhaust system **2800**. In yet another embodiment, the exhaust system **2800** may be controlled both automatically and manually.

In one embodiment, the temperature sensor **2852** may detect the internal temperature of the catalytic converter **2818**. The controller **2802** may utilize the temperature data received from the temperature sensor **2852** to control the heater **2820**. That is, the controller **2802** may control the heater **2820** to maintain a desired temperature inside of the catalytic converter **2818** to achieve desired performance (e.g., sufficient reduction of harmful exhaust gases and particulate matters) and/or functionality of the catalytic converter **2818**.

In one embodiment, the SCR **2824** may be controlled in the similar manner as described in relation to the catalytic converter **2818**. That is, the controller **2802** may receive signals from the gas sensors **2854**, **2856** and the temperature sensors **2855**, **2858** to control the dosing injector **2812** and the heaters **2826**, similarly to controlling the catalytic converter **2818** as described above, to achieve desired performance and/or functionality of the SCR **2824**. In some embodiments, more than one SCR may be utilized in the exhaust converter system **2807** to further reduce or remove the harmful exhaust gases and particulate matters.

In one embodiment, the controller **2802** may receive data from an altitude sensor **2860**. The altitude sensor **2860** may be mounted on any suitable location of a vehicle. Since the level of altitude may offset the pressures within the engine and the exhaust converter system **2807**, the controller **2802** may perform appropriate functions to offset the pressure variance caused by the change in altitude. For example, at relatively higher altitude the exhaust system **2800** may intake relatively less oxygen in the engine **2804**. Accordingly, the controller **2802** may transmit control signals to adjust a throttle position switch to introduce additional air into the engine **2804**. The change in altitude may affect fuel efficiency as well as air pressure in the engine. That is, at a relatively higher altitude level, the engine may burn less gas. Further, relatively less air with more fuel may cause damage, for example, to the catalytic converter **2818**. As such, the controller **2802** may transmit appropriate signals to various components (e.g., throttle position switch, heaters, etc.).

FIG. **28**A shows an exemplary dosing solution distributor **2851** according to an embodiment of the present disclosure. The dosing solution distributor **2851** is located downstream of one or more dosing injectors **2810**, **2812**. The one or more dosing solution distributors **2851** may be located between the dosing injectors **2810**, **2812** and the catalytic converter **2818** and the SCR **2824**, respectively. The dosing solution distributor **2851** may include a plurality of wings (or plates) **2895** disposed at a predetermined distance from each other. Further, the dosing solution distributor **2851** may include a plurality of openings **2899** between each of the wings **2895**, and a circular aperture **2897** at the center of the dosing solution distributor **2851**, as shown in FIG. **28**A. The dosing solution distributor **2851** prevents deterioration (e.g., cracking) of a honeycomb filter in a catalytic converter and/or an SCR by evenly distributing the dosing solution sprayed by the dosing injectors **2810**, **2812**. In one embodiment, each of the wings **2895** may be angled at a predetermined angle to give a turbine effect and to distribute the dosing solution evenly to the filter of a catalytic converter and/or an SCR. The shape, size, and number of the wings **2895** are not limited thereto, and may be varied according to the desired application or performance of the dosing solution distributor **2851**.

FIG. **29** illustrates a schematic view of an exemplary exhaust control system **2900** for operation and/or control of an exhaust system according to an embodiment of the present disclosure. The exhaust control system **2900** may include a plurality of inputs **2901**, for example, gas data **2906**, temperature data **2908**, and altitude data **2910**, a controller **2902**, and a plurality of outputs **2903**, for example, gas monitoring data **2912**, heater adjustment value **2914**, injector adjustment value **2916**, and throttle position switch signal value **2918**. The controller **2902** may include a determination module **2904**, a memory, a secondary storage device, and a processor, such as a central processing unit or any other means for accomplishing a task consistent with the present disclosure. The memory or secondary storage device associated with the controller **2902** may include non-transitory computer-readable media and may store data and/or software routines that assist controller **2902** in performing its functions, such as the process disclosed in relation to the exhaust system **2800** of FIG. **28**. Further, the memory or secondary storage device associated with the controller **2902** may store data received from various inputs associated with the sensors disclosed in the exhaust system **2800** or other systems of the present disclosure. Commercially available microprocessors may be configured to perform the functions of the controller **2902**. It should be appreciated that the controller **2902**, could readily embody a general machine controller capable of controlling numerous other machine functions. Various other known circuits may be associated with controller **2902**, including signal-conditioning circuitry, communication circuitry, actuation circuitry, and other appropriate circuitry.

In one embodiment, the controller **2902** may control one or more heaters (e.g., heaters **2818**, **2826**). For example, based on the temperature data **2908** received from one or more temperature sensors (e.g., temperatures sensors **2853**, **2852**, **2858**) according to the foregoing embodiments of FIGS. **1-28**, the determination module may calculate or determine a heater adjustment value **2914**. The controller **2902** may then transmit the heater adjustment value **2914** to control the one or more heaters (e.g., heaters **2818**, **2826**) in accordance with the foregoing embodiments of the present disclosure.

In one embodiment, the controller **2902** may control one or more dosing injectors **2810**, **2812**. For example, based on the temperature data **2908**, the determination module **2904** may calculate or determine an injector adjustment value **2916**. The controller **2902** may then transmit the injector adjustment value **2916** to control to the one or more dosing injectors **2810**, **2812** in accordance with the foregoing embodiments of the present disclosure. In one embodiment, the determination module **2904** may utilize the altitude data **2910**, to calculate or determine the throttle position switch signal value **2918**. The controller **2902** may then control a throttle position switch in accordance with the foregoing embodiments of the present disclosure. In one embodiment, the determination module **2904** may generate gas monitoring data **2912** based on gas data **2906** received from one or more gas sensors (e.g., **2850**, **2854**, **2856**). For example, the determination module may compare the amount gas detected by the gas sensor **2850** and the gas sensor **2854**. The determination module may then generate gas monitoring data **2912**. The controller **2902** may then transmit the gas monitoring data **2912** to a display according to the foregoing embodiments according to the present disclosure. In some embodiments, the determination module **2904** may utilize gas data **2906**, temperature data **2907**, and altitude data **2910** simultaneously or sequentially to determine appropriate data and values for controlling the heaters, injectors, throttle position switches, and/or displays in accordance with the embodiments of the present disclosure. Accordingly, the controller **2902** may be configured to facilitate automatic and/or manual control of the heaters, injectors, throttle position switches, and/or displays according to the embodiments of the present disclosure.

In one embodiment, a catalytic converters according to the foregoing embodiments may be placed or arranged so that exhaust gases may flow from one or more inlet ports according to the foregoing embodiments through one or more disruptor plates (in some embodiments) of the foregoing embodiments, and through one or more heaters or heating elements of the foregoing embodiments. Additionally, the exhaust gases may be additionally heated in some embodiments by one or more additional heaters and subjected to magnetic fields by the magnets of the foregoing embodiments. The additional heaters and/or magnetic fields may interact with the individual molecules and ions of the gases passing through catalytic converters and increase the efficiency of catalytic conversion that takes place before exiting a catalytic converter. In addition to heaters being included within a catalytic converter, the heaters may be added to existing catalytic converters on a vehicle or a machine.

According to testing results, exhaust systems equipped or modified according to the foregoing embodiments of the present disclosure resulted in carbon emissions, waste gases (NOx, CO, etc.) and particulate matters reduction by, about, 95-99% in gasoline powered cars and 90-97% in diesel power cars.

FIGS. **30**A and **30**B illustrate an embodiment of an exhaust system **3100** for a vehicle that runs on diesel fuel. As shown in FIGS. **30**A and **30**B, the exhaust system **3100** may include an oxidation catalyst **3102**, a diesel particulate filter (DPF) **3104**, a selective catalytic reduction filtration system (SCR) **3108**, and a muffler **3112**. Although the oxidation catalyst **3102**, and DPF **3104**, and SCR **3108** are shown separately, in some embodiments, the oxidation catalyst **3102**, DPF **3104**, and/or SCR **3108** may be combined into a single unitary system included in a single housing. The exhaust system **3100** may further include a first tubing **3106** that connects the oxidation catalyst **3102** to the diesel particulate filter **3104**, and a second tubing **3110** that connects the DPF **3104** to the SCR **3108**, and a third tubing **3114** that connects SCR **3108** to the muffler **3112**. The exhaust system **3100** may also include heaters **3124**, **3149** and sensors **3140**, **3141**, **3142**.

FIG. **30**C shows an exhaust system **3150** according to another embodiment of the present disclosure. The exhaust system **3150** may include the similar components as those shown in FIGS. **31**A and **33**B. In addition, the exhaust system **3150** may include an additional SCR **3152** including an injector **3154**. The additional SCR **3152** and the injector **3154** in this embodiment may facilitate additional reduction and removal of the harmful gases after being treated by the oxidation catalyst **3102**, the diesel particulate filter **3104**, and the SCR **3108**.

As depicted in FIG. **31**, the oxidation catalyst **3102** may include a housing **3216**, an inlet **3218** where exhaust gases enter a cavity **3220** of the housing **3216** and an outlet **3222** where the exhaust gases exit the housing **3216**. An oxygen sensor (e.g., **02** sensor) may be fixed externally to the housing **3216** and may extend into the cavity **3220**, downstream of the inlet **3218** to assess the percentage of oxygen in the exhaust gas. An electric heater **3124** (see FIG. **32**) may extend into the cavity **3220** from outside of the housing **3216**. The heater **3124** may be connected external of the oxidation catalyst **3102** to a power source and an electronic control unit. The heater **3124** depicted in FIG. **30**A may include a wound metal coil **3125**. However, the heater **3124** can take any form to ensure internal hearting of the oxidation catalyst **3102**. To assess the temperature of the exhaust gas prior to exiting the oxidation catalyst **3102**, a heat sensor may be located near the inlet **3218** and/or outlet **3222**.

As shown in FIG. **31**, within the cavity **3220** of the housing **3216**, downstream of the heater **3124**, at least one filter **3226** is arranged. The filter **3226** is configured to filter harmful gases and particulate including, but not limited to, carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxide (NOx) as well as hydrocarbons (HC), particulate matter (PM) and other harmful chemicals and debris. The filter **3226** may be formed of, for example, ceramic, and may be coated with one or more noble metals **3228** (such as described above in FIG. **2**B) and may include a plurality of honeycomb shaped openings. The openings of the filter **3226** are configured to disrupt the flow of exhaust gases and trap particulate matter to prevent the particulate matter from being emitted into the environment.

A plurality of rods **3230**, which may be formed of a heat-treated metal or alloy (e.g., copper or steel) may extend longitudinally through the honeycomb structure of the filter **3226**. The rods **3230** may also or instead extend across the filter **3226**. Additionally, one or more magnets **3232** may be disbursed inside of the housing **3216**. The magnets **3232** may be arranged near or in contact with the filter **3226** and/or within the filter **3226**.

Similar to an engine that utilizes gasoline as disclosed above in reference to FIG. **16**, upon startup of a diesel engine that utilizes the exhaust system **3100** from a cold start, the electric heater **3124** may simultaneously be turned on by an electronic control unit (ECU) to aid in heating the internal temperature of the oxidation catalyst **3102**, DPF **3104**, and SCR **3108** above a temperature of the exhaust gases and particulate matters. The heater **3124** may remain on after reaching a desired temperature or it may be turned off and then turned back on if the temperature within the oxidation catalyst **3102**, DPF **3104**, and/or SCR **3108** drops below a threshold temperature. The rods **3230** are configured to accelerate heating the internal temperature of the oxidation catalyst **3102** to a desired internal temperature and aid in maintaining the desired internal temperature at least throughout the filter **3226** and surrounding internal surface area.

By increasing the internal temperature of the oxidation catalyst **3102**, harmful chemicals and particulates that are part of the exhaust gas are oxidized and/or burned off before exiting the oxidation catalyst **3102**. The noble metal filter coating **3228** aids to further slow and disrupts the flow of the exhaust gases traversing across the inside of the cavity of the oxidation catalyst **3102** such that more of the harmful exhaust emissions can be heated above a threshold temperature and burn off prior to exiting the oxidation catalyst **3102**.

The magnets **3232** further disrupt and slow the flow of exhaust gases and particulates as they pass through the oxidation catalyst **3102**, similar to the magnets **1232**, **1632**, **1646** incorporated into the gasoline exhaust system **1600** and catalytic converter **1200**, by increasing the electric current within the cavity **3220** of the oxidation catalyst **3102** via the polarity of the magnets **3232**. Disrupting and slowing the flow of exhaust gases and particulates allows for heating of the exhaust gases for a longer period of time within the cavity **3220** of the oxidation catalyst **3102** and in turn further oxidization and reduction of toxic byproducts of exhaust gases. Upon exiting the oxidation catalyst **3102**, the remaining harmful exhaust gases, particulates and debris travel through the tubing **3110** and into the diesel particulate filter **3104**. The diesel particulate filter **3104** may be designed to trap particulates (e.g. soot) after they exit the oxidation catalyst **3102** and prior to exiting the exhaust system **3100** and being emitted into the environment.

As shown in FIG. **32**, the diesel particulate filter **3104** includes a ceramic filter **3105** that may have a plurality openings (e.g., honeycomb shaped openings) that are configured to trap particulates (e.g., soot) to prevent the particulates from being emitted into the environment. Similar to the filters of the foregoing embodiments of the present disclosure, the filter **3105** may be coated with one or more noble metals **3336** and may include a plurality of rods **3338** that extend through the honeycomb structure. The rods **3338** may be formed of a heat-treated metal or alloy (e.g., copper or steel). Additionally, one or more magnets **3339** may be disbursed near or in contact with the filter **3105** and/or within the filter **3105**.

In order to reduce the particulate matter that has accumulated on the filter **3105** and prevent the particulate matter from blocking the filter **3105** and in turn creating backpressure in the exhaust system **3100**, the filter **3105** must be cleaned through regeneration by burning off the particulate that has accumulated on the filter **3105**. There are two types of regeneration-active regeneration and passive regeneration. Active regeneration involves raising the actual exhaust gas temperature by introducing additional thermal energy. In contrast, passive methods are based on lowering the required temperatures to a range within which the available temperature is adequate for regeneration. Unlike existing regeneration systems, a heater **3140**, which communicates with an electronic control unit, may be placed upstream of the DPF **3104** and may be used in combination with the rods **3338**, noble metal coating **3336** and one or more magnets **3339** arranged within the DPF **3104** to increase the electrical current (via the magnets **3339**), disrupt the flow of exhaust gases and particulate matter (via the noble metal coating **3336**) and raise the temperature of the filter **3105** (via the rods **3338**) and in turn raise the temperature of the particulates that are trapped on and within the filter to oxidize the particulate and create a gaseous byproduct (i.e., CO_2). Additionally, the percentage of nitrogen dioxide in the exhaust gas is reduced and converted to nitrogen monoxide. This chemical process is constantly repeated so that the filter **3105** may be continuously cleaned during regular operation of the exhaust system. As such, no additional aid may be needed with regeneration, for example, with the assistance from an engine management system.

Downstream of the diesel particulate filter **3104** is the selective catalytic reduction system **3108**, which, similar to the SCR **1604** in the gasoline exhaust system **1600**, is configured to reduce nitrogen dioxide gases by oxidizing them and converting them into harmless exhaust emissions (e.g., nitrogen, water, and a small amount of carbon dioxide) that are emitted out of the exhaust system **3100** and into the environment without the need to introduce a liquid-reductant agent that into the exhaust stream.

The SCR **3108** may include a filter **3342** having a plurality of openings (e.g., honeycomb shaped openings) **3344** and small holes **3346** dispersed about the filter **3342**. Similar to the SCR **1604** in the gasoline exhaust system **1600**, the filter **3342** may be coated with one or more noble metals **3348** (such as described above in FIG. **2**B), and may include a plurality of rods **3350** that extend through the honeycomb structure and one or more magnets **3347** dispersed about the filter **3342**.

Referring to back FIG. **30**A, an electric heater **3149**, which communicates with an electronic control unit, may be provided in the selective catalytic reduction system **3108**, upstream of filter **3342**. The heater **3149** may be configured to raise the internal temperature of the selective catalytic reduction system **3108** above a threshold temperature in conjunction with the rods **3350** and metal coating **3348** to ensure that the internal temperature across the filter **3342** and surrounding internal surface area is greater than the temperature of the remaining exhaust gases and particulate matter and is maintained to further reduce the percentage of nitrogen oxide gases as they travel across the filter **3342**. The small holes **3346** and magnets **3347** may be included to aid in further disrupting the flow of exhaust gases as they travel within the selective catalytic reduction system **3108** and to provide more time for the exhaust gases to oxidize and/or be burned off as they pass through the heated selective catalytic reduction system **3108** before exiting. The SCR **3108** may include one or more nitrogen oxide sensors to ensures that the SCR **3108** operates efficiently.

Upon exiting the SCR **3108**, the remaining exhaust gases may flow through the tubing **3114** to the muffler **3112**. The muffler **3112** may be substantially similar to the muffler **1608** for the gasoline exhaust system **1600**. As depicted in FIGS. **25** and **26**, the muffler **3112** may include a housing in which one or more silencers and a plurality of plates that are interspersed and/or spaced from each other are located. The plates, which can, for example, be formed of steel, are coated with one or more noble metal(s). The noble metal coating (such as described above in FIG. **2**B) may aid to disrupt the flow of the exhaust gases within the housing such that they become turbulent, which in turn slows the flow of the hot exhaust gases as they pass from an inlet of the muffler

3112 through and exit the muffler housing though an outlet. The disruption of the exhaust gases within the muffler 3112 due to the inclusion of the noble metal coated plates allows the exhaust gases and particulate matter more time within the muffler 3112 to burn off and/or oxidize prior to exiting the muffler 3112 and entering the environment.

According to another embodiment of the invention, one or more heaters 4220 may be attached to or disposed inside one or more of various exhaust pipes 4210 (e.g., connection pipes, extension pipes, etc.) of an exhaust system 4200 (herein, "exhaust pipe heater"), such as shown in FIGS. 42 and 43. The exhaust pipes 4210 may be made from aluminized or stainless steel.

For example, in an exhaust system 4200 for a gasoline powered engine, one or more exhaust pipe heaters 4220 may be disposed inside the exhaust pipe 4210 at a location that is before the inlet port of the catalytic converter, between the catalytic converter and the SCR, and/or between the SCR and the muffler. Similarly, in an exhaust system 4200 for a diesel powered engine, one or more exhaust pipe heaters 4220 may be disposed within the exhaust pipe 4210 at a location that is before the diesel oxidation catalyst, between the diesel oxygen catalyst and the DPF, and/or between the DPF and the SCR. The exhaust pipe heaters 4220 may receive power from a power supply (not shown) via an electrical connector 4225 (such as electrical connectors 1724, 1734 described above). The exhaust pipe heaters may be separately powered via separate electrical connectors 4225 or powered together via a single electrical connector 4225. In a gasoline or diesel powered vehicle, the exhaust pipe heaters 4220 may be electrically connected to and powered by the vehicle's primary battery (not shown) or alternatively a secondary battery (not shown) via one or more electrical connectors 4225.

The exhaust pipe heaters 4220 can be installed within an existing exhaust pipe 4210 of an exhaust system 4200 or as part of a replacement exhaust pipe 4210 for an existing exhaust system. For example, the replacement exhaust pipe 4210 having the one or more exhaust pipe heaters 4220 may be connected to the exhaust manifold, the catalytic converter, the SCR, and/or the muffler of the exhaust system 4200. It is understood that some catalytic converters are integrated into the exhaust manifold.

As shown in FIGS. 42 and 43, the exhaust pipe 4210 may further comprise a dosing system 4230. The dosing system 4230 may include a dosing injector 4240 (such as dosing injectors 2810, 2812 described above) coupled to a dosing solution tank 4250 (such as dosing solution tanks 2806, 2808 described above) for injecting or pumping a dosing solution, such as a urea, salt water, or ammonia solution, among other possible solutions, to the exhaust flow gas. The exhaust pipe 4210 may further include one or more gas sensors 4270 (such as gas sensors 2850, 2854, 2856 described above). Additionally, the exhaust pipe may include a temperature sensor (such as temperature sensors 2852, 2853, 2855, 2858 described above), The dosing solution may be injected into the exhaust pipe 4210 at a predetermined temperature or a predetermined temperature range to further improve reduction or removal of harmful gases (e.g., NOx, etc.) in the exhaust pipe 4210.

Accordingly, as discussed above, a controller (such as controller 2802 described above) (not shown) may receive signals from the gas sensors 4270 and/or temperature sensor to control an amount of current supplied to the heater and the timing in which the current is supplied to the exhaust pipe heater 4220 based on the received signals. Additionally, the dosing system 4230 may receive signals from the controller to control a timing and a duration of the dosing solution spray based on signals received from the one or more sensors. For example, when a predetermined temperature in the exhaust pipe 4210 is detected by the temperature sensor, the controller may send command signals to the dosing injector to inject or shoot dosing solution into the exhaust pipe based on the detected temperature. In one embodiment, the dosing injector 4240 may continuously inject dosing solution supplied by the dosing solution tank 4250 into the exhaust pipe 4210 at a predetermined interval if the temperature sensor detects that a predetermined temperature is maintained. Alternatively, the temperature sensor may be configured to detect a predetermined temperature range, for example, about 340 to 410 degrees Celsius. In other words, the dosing solution injected into the exhaust pipe 4210 at the predetermined temperature or the predetermined temperature range may improve reduction or removal of harmful gases (e.g., NOx, etc.) in the exhaust pipe 4210. Additionally, the temperature sensor may detect the internal temperature of the exhaust pipe. The controller may utilize the temperature data received from the temperature sensor to control the exhaust pipe heater 4220. That is, the controller may control the exhaust pipe heater 4220 to maintain a desired temperature inside of the exhaust pipe 4210 to achieve desired performance (e.g., sufficient reduction of harmful exhaust gases and particulate matters) and/or functionality of the exhaust system.

Additionally, the exhaust pipe 4210 may include one or more magnets (such as magnets 607 described above) located or arranged on or adjacent to an exterior surface 4215 of the exhaust pipe 4210. The magnets (not shown herein) may have a curved shape to approximate the outer geometry of the exhaust pipe and may be disposed in an array having alternating polarities (such as shown in FIG. 7 above). In one embodiment, the magnets facing each other may have opposing polarities. Alternatively, the magnets may have the same polarity and the polarity may not vary along the longitudinal or horizontal direction of the exhaust pipe 4210. Having magnets facing each other with opposite polarities results in a stronger magnetic field. In one embodiment, the plurality of magnets may include one or more neodymium magnets. In another embodiment, the one or more magnets may be electromagnets. However, any suitable magnets may be used depending on the desired application. Additionally, the exhaust pipe 4210 may include an outer shell or an outer surface (e.g., tape, fastener, covering, etc.) (not shown) and one or more of the magnets may be arranged or disposed between an exterior surface of the exhaust pipe and the outer shell. Additionally, the exhaust pipe may comprise one or more filters 4260 (such as filter 110 described above).

According to an embodiment, the exhaust pipe 4210 is configured to be coupled to an exhaust system component. The exhaust system component may include one or more of the following: an exhaust manifold, a catalytic converter, a selective catalytic reduction system (SCR), a diesel oxidation catalyst, a diesel particulate filter (DPF), a selective catalytic reduction system (SCR), and a muffler. The exhaust pipe 4210 may include an exhaust pipe heater 4220 disposed inside a cavity 4280 of the exhaust pipe 4210. The exhaust pipe heater 4220 may include a housing 4290, a heating wire disposed inside the housing (such as heating wires 1804, 1906 described above), and an electrical connector 4225 attached to the housing and electrically connected to the heating wire. The electrical connector 4225 may be configured to receive power from a power supply (not shown) that is external from the exhaust pipe heater 4220 to supply electrical current to the heating wire. The exhaust pipe heater **4220** may be configured to heat gas inside the exhaust pipe **4210** to reduce toxic gases and/or particulate matter exiting the exhaust pipe **4210**. The exhaust pipe **4210** may further include one or more magnets arranged adjacent to an exterior surface **4215** of the exhaust pipe **4210** to aid in disruption and slowing of the flow of exhaust gases in the cavity **4280** of the exhaust pipe **4210**. The exhaust pipe **4210** may further include a second surface (not shown) that is positioned outside of the exterior surface **4215** and the one or more magnets may be disposed between the second surface and the exterior surface **4215** of the exhaust pipe **4210**. The second surface may be a surface of an exterior shell, an exterior casing, tape or other adhesive, a fastener, etc.

The exhaust pipe **4210** may include an exhaust pipe heater **4220** disposed inside a cavity **4280** of the exhaust pipe **4210**. The exhaust pipe heater **4220** may include a housing **4290**, a heating wire disposed inside the housing (such as heating wires **1804**, **1906** described above), and an electrical connector **4225** attached to the housing and electrically connected to the heating wire. The electrical connector **4225** may be configured to receive power from a power supply (not shown) that is external from the exhaust pipe heater **4220** to supply electrical current to the heating wire. The exhaust pipe heater **4220** may be configured to heat gas inside the exhaust pipe **4210** to reduce toxic gases and/or particulate matter exiting the exhaust pipe **4210**. The exhaust pipe **4210** may further include one or more magnets arranged adjacent to an exterior surface **4215** of the exhaust pipe **4210** to aid in disruption and slowing of the flow of exhaust gases in the cavity **4280** of the exhaust pipe **4210**. The exhaust pipe **4210** may further include a second surface (not shown) that is positioned outside of the exterior surface **4215** and the one or more magnets may be disposed between the second surface and the exterior surface **4215** of the exhaust pipe **4210**. The second surface may be a surface of an exterior shell, an exterior casing, tape or other adhesive, a fastener, etc.

FIG. **44** shows an external heater **4400** according to an embodiment of the invention. The external heater **4400** may be located external and be connected to one or more components of an exhaust system. The one or more components may be a catalytic converter, a selective catalytic reduction system (SCR), a diesel oxidation catalyst, a diesel particulate filter (DPF), a selective catalytic reduction system (SCR), a muffler, or exhaust pipes of the exhaust system (shown in FIG. **46**).

In one embodiment, the external heater **4400** has a heater housing **4420**, which may be made of steel or aluminum (not limited thereto), and a heating wire **4410** (such as heating wires **1804**, **1906** described above) or alternative a heating element disposed therein. The heating wire **4410** is not limited to any configuration or shape. The external heater **4400** may further include a connection pipe **4440** (such as a metal or flexible connection pipe or other attachment means such as connection pipe **4615** described below) and a temperature sensor **4450** (such as temperature sensors **2852**, **2853**, **2855**, **2858** described above). Temperature sensor **4450** may also function as an altitude sensor. The external heater **4400** may further include a dosing system **4430**. The dosing system **4430** may include a dosing injector (such as dosing injectors **2810**, **2812**, **4240** described above) coupled to a dosing solution tank (such as dosing solution tanks **2806**, **2808**, **4250** described above) for injecting or pumping a dosing solution, such as a urea, salt water, or ammonia solution, among other possible solutions, into the exhaust system. The dosing solution may be injected into the external heater **4400** at a predetermined temperature or a predetermined temperature range to further improve reduction or removal of harmful gases (e.g., NOx, etc.) in the exhaust system. The external heater **4400** may receive power from a power supply (not shown) via an electrical connector (such as electrical connectors **1724**, **1734** described above) or via first and second terminals **4460** and **4465**. For example, first terminal **4460** may be a positive terminal and second terminal **4465** may be a negative terminal. In a gasoline or diesel powered vehicle, the external heater **4400** may be electrically connected to and powered by the vehicle's primary battery (not shown) or alternatively a secondary battery (not shown) via first and second terminals **4460** and **4465**.

FIG. **45** shows an external heater **4500** according to another embodiment of the invention. The external heater **4500** may be located external and be connected to one or more components of an exhaust system. The one or more components may be a catalytic converter, a selective catalytic reduction system (SCR), a diesel oxidation catalyst, a diesel particulate filter (DPF), a selective catalytic reduction system (SCR), a muffler, or exhaust pipes of the exhaust system (shown in FIG. **46**).

In one embodiment, the external heater **4400** has a heater housing **4520**, which may be made of steel or aluminum (not limited thereto), and a plurality of heating elements **4510**, **4515** disposed therein (such as heating elements **1908**, **2008**, **2717** described above). The heating elements are **4510**, **4515** is not limited to any configuration or shape. The heating elements **4510**, **4515** may include a heating wire (such as heating wires **1804** and **1906** described above) and/or a heating element, for example, a honeycomb or hexagonal shape heater as described above. Thus, the heating elements **4510**, **4515** may act as a filter and may include a catalyst coating such as shown in FIG. **2**B to aid in the removal or reduction of harmful gases and particulate matters.

The external heater **4500** may further include a connection pipe **4540** (such as a metal or flexible connection pipe or other attachment means such as connection pipe **4615** described below) and a temperature sensor **4550** (such as temperature sensors **2852**, **2853**, **2855**, **2858**, **4450** described above). Temperature sensor **4550** may also function as an altitude sensor. The external heater **4500** may further include a dosing system **4530**. The dosing system **4530** may include a dosing injector (such as dosing injectors **2810**, **2812**, **4240** described above) coupled to a dosing solution tank (such as dosing solution tanks **2806**, **2808**, **4250** described above) for injecting or pumping a dosing solution, such as a urea, salt water, or ammonia solution, among other possible solutions, into the exhaust system. The dosing solution may be injected into the external heater **4500** at a predetermined temperature or a predetermined temperature range to further improve reduction or removal of harmful gases (e.g., NOx, etc.) in the exhaust system. The external heater **4500** may receive power from a power supply (not shown) via an electrical connector (such as electrical connectors **1724**, **1734** described above) or via first and second terminals **4560** and **4565**. For example, first terminal **4560** may be a positive terminal and second terminal **4565** may be a negative terminal. In a gasoline or diesel powered vehicle, the external heater **4500** may be electrically connected to and powered by the vehicle's primary battery (not shown) or alternatively a secondary battery (not shown) via first and second terminals **4560** and **4565**.

FIG. **46** shows an exhaust system **4600** that incorporates one or more external heaters **4610** (such as external heaters

4400 and 4500 described above). In one embodiment, the exhaust system 4600 includes, but is not limited to, a catalytic converter or DPF 4690, exhaust pipes 4692, a SCR 4694 and a muffler 4696. The external heater 4610 may be connected to any one or more of the foregoing components of the exhaust system 4600. In FIG. 46 the external heater 4610 is located external and connected to the catalytic converter/DPF 4690. It is understood that the external heater 4610 can be connected to a different component, such as at an inlet of the SCR 4694, or to both the catalytic converter/DPF 4690 and the SCR 4694 (or other component, such as one or more exhaust pipe 4692).

The external heater 4610 may be connected to the exhaust system component—in this embodiment the catalytic converter/DPF 4690—via a connection pipe 4615, such as a metal or flexible connection pipe or other attachment means. Alternatively, the external heater 4610 may be directly coupled to the exhaust system component by either forming a hole and fastening the external heater 4610 to the hole or by using an existing sensor hole in the exhaust system component.

The external heater 4610 may include one or more temperature sensors 4650 (such as temperature sensors 2852, 2853, 2855, 2858, 4450, 4550 described above). Temperature sensor 4650 may also function as an altitude sensor. The external heater 4610 may further include a dosing system 4630. The dosing system 4630 may include a dosing injector (such as dosing injectors 2810, 2812, 4240 described above) coupled to a dosing solution tank 4635 (such as dosing solution tanks 2806, 2808, 4250 described above) for injecting or pumping a dosing solution, such as a urea, salt water, or ammonia solution, among other possible solutions, into the exhaust system. The dosing solution may be injected into the external heater 4610 at a predetermined temperature or a predetermined temperature range to further improve reduction or removal of harmful gases (e.g., NOx, etc.) in the exhaust system. The external heater 4610 may receive power from a power supply (not shown) via an electrical connector (such as electrical connectors 1724, 1734 described above). In a gasoline or diesel powered vehicle, the external heater 4500 may be electrically connected to and powered by the vehicle's primary battery (not shown) or alternatively a secondary battery (not shown).

The exhaust system 4600 may further include one or more gas sensors 4640 (such as gas sensors 2850, 2854, 2856 described above). The gas sensors 4640 may include, for example, an oxygen (e.g., O_2) sensor, but are not limited thereto and any suitable gas sensor may be utilized based on the desired application of the exhaust system 4600. Each of the gas sensors 4640 may be controlled by a dedicated controller 4645 that is separate from, for example, an existing controller of the vehicle exhaust system.

The catalytic converter/DPF 4690 may include one or more magnets 4670 located or arranged adjacent to or on an exterior surface of the catalytic converter/DPF 4690. The one or more magnets 4670 may be disposed in an array having alternating polarities as shown in FIG. 7. In one embodiment, the magnets 4670 facing each other may have opposing polarities. Alternatively, the one or more magnets 4670 may have the same polarity and the polarity may not vary along the longitudinal or horizontal direction of the catalytic converter/DPF 4690. Having magnets facing each other with opposite polarities results in a stronger magnetic field. In one embodiment, the plurality of magnets 4670 may include one or more neodymium magnets. In another embodiment, the one or more magnets 4670 may be electromagnets. However, any suitable magnets may be used depending on the desired application. It is understood that the one or more magnets 4670 may be located adjacent or on an exterior surface of other components of the exhaust system, such as the SCR 4694, muffler 4696, and/or exhaust pipes 4692.

Additionally, gas sensors 4640 may be coupled external to one or more components of the exhaust system 4600. In FIG. 46, a first gas sensor 4640 is coupled to the catalytic converter/DPF 4690 and a second gas sensor 4640 is couple to an exhaust pipe 4692 attached to an outlet port of the catalytic converter/DPF 4690. The gas sensors 4640 may include, for example, an oxygen (e.g., O_2) sensor, but are not limited thereto and any suitable gas sensor may be utilized based on the desired application of the exhaust system 4600. Each of the gas sensors 4640 may be controlled by a dedicated controller 4645 that is separate from, for example, an existing controller of the vehicle exhaust system.

Additionally, temperature sensors 4450 may be coupled externally to one or more components of the exhaust system 4600. For example, as illustrated in FIG. 46, a temperature sensor 4650 is coupled externally to an exhaust pipe 4692 attached to an outlet port of the catalytic converter/DPF 4690. Temperature sensor 4650 may also function as an altitude sensor.

Additionally, the exhaust system may be coupled to a controller 4680. The controller 4680 may receive signals from the temperature sensors 4650 to controls the external heater 4610. Further, the controller 4680 may receive signals from the temperature sensors 4650 to control the dosing system 4630. For example, when a predetermined temperature in the catalytic converter/DPF 4690 is detected by the temperature sensor 4650, the controller 4680 may send command signals to the dosing system 4630 to inject or shoot dosing solution into the catalytic converter/DPF 4690. In one embodiment, the dosing system 4630 may continuously inject dosing solution supplied by the dosing solution tank 4635 into the catalytic converter/DPF 4690 at a predetermined interval if the temperature sensor 4650 detects that a predetermined temperature is maintained. Alternatively, the temperature sensor 4650 may be configured to detect a predetermined temperature range, for example, about 340 to 410 degrees Celsius. In other words, the dosing solution injected into the catalytic converter/DPF 4690 at the predetermined temperature or the predetermined temperature range may improve reduction or removal of harmful gases (e.g., NOx, etc.) in the catalytic converter/DPF 4690.

In one embodiment, the gas sensors 4640 may transmit data related to the condition or state of the exhaust gas to the dedicated controller 4645. Accordingly, the controller 4645 may utilize the received gas data to monitor the effectiveness of the catalytic converter/DPF 4690 and to perform appropriate functions to achieve desirable performance of the catalytic converter/DPF 4690.

FIG. 34 illustrates an exhaust system 3400 for a coal burning apparatus, device or the like. The exhaust system 3400 includes a housing 3402. Sequentially, within the housing 3402 is a first selective catalytic reduction filtration system (SCR) 3406 directly downstream of an inlet 3404, a first electric heater 3408, a second SCR 3410, a second heater 3412 and another filter 3413 with a honeycomb structure. Additionally, dispersed about the interior of the housing 3402, near the internal sidewall is a plurality of magnets 3415. The design and properties of the SCR 3406, 3410 and heaters 3408, 3412 may be substantially similar to the foregoing embodiments discussed above with regard to the gasoline and diesel exhaust systems 1600, 3100, and as such the substantially similar features are incorporated by references as part of the exhaust system **3400**.

Downstream of the exhaust system **3400** in FIG. **34** is a first electric blower **3414**, a plurality of filters **3416** that include a honeycomb structure **3517** (see details in FIGS. **35**A and **35**B), chutes **3219** that direct unburned particles (e.g., coal) to a waste bin **3418** in which the unburned particles are disposed, an additional metal filtration system **3420**, a second electric blower **3432** and a smoke stack **3424** through which clean gases exit into the environment.

FIG. **36** depicts an exhaust system **3600** for a motorcycle. As shown in FIG. **36**, a first selective catalytic reduction filtration system (SCR) **3602** may be arranged within an exhaust tubing **3604** and an electric heater **3606** and a second SCR **3608** may be arranged within an exhaust housing **3609**. As shown in FIG. **36**, the heater **3606** may be arranged to extend within the housing **3609** near an inlet **3612** of the housing **3609** with the second SCR **3608** located downstream of the heater **3606**. In one embodiment, the first SCR **3602** and the second SCR **3608** may include copper ceramic. The heater **3606** may be configured to operate using the desired voltage (e.g., 6-45 amps) of the vehicle.

The first and second SCR **3602**, **3608**, like the SCR of the foregoing embodiments discussed above, are configured to reduce nitrogen oxide gases by oxidizing the nitrogen oxide gases and converting them into harmless exhaust emissions that are emitted out of the exhaust system **3600** and into the environment with or without the need to introduce a liquid-reductant agent into the selective catalytic reduction filtrations systems **3602**, **3608**. The first and second SCRs **3602**, **3608** each, respectively, may include a filter **3614**, **3615** that may include a plurality of honeycomb shaped openings coated with one or more noble metals **3616**, **3617**, a plurality of rods **3618**, **3619** formed of a metal or alloy that may extend longitudinally through the honeycomb structure and one or more magnets **3620**, **3621**. Additionally or alternatively, the rods **3618**, **3619** may extend to traverse about the filter **3614**, **3615**. The rods **3618**, **3619** and noble metal coating **3616**, **3617** (such as described above in FIG. **2**B) facilitates rapid heating of the first and second SCRs **3602**, **3608**, and ensure the internal temperature across the filters **3614**, **3615** is maintained. The magnets **3620**, **3621** may be arranged and disbursed within the filters **3614**, **3615** to aid, through their polarity, to further disrupt and slow the flow of exhaust gases and particulates as they pass over the filters **3614**, **3615** by increasing the electric current in the vicinity of the magnets **3620**, **3621** to allow for heating of the exhaust gases for a longer period of time within each respective selective catalytic reduction system **3602**, **3608** and in turn further oxidization and reduction of toxic byproducts of exhaust gases. Additionally or alternatively, the placement of the magnets **3620**, **3621** within the filter **3614**, **3615**, the magnets **3620**, **3621** may be arranged adjacent to the filters **3614**, **3615** and/or external each respective selective catalytic reduction system **3602**, **3608** housing. While two selective catalytic reduction systems **3602**, **3608** are shown, exhaust system **3600** may include a single selective catalytic reduction system **3608** in the housing **3609**.

FIG. **37** depicts an exhaust system **3700** for a lawnmower. As shown, an electric heater **3702** and a selective catalytic reduction filtration system **3704** may be arranged within an exhaust housing **3706**. The heater **3702** may be arranged to extend within the housing **3706** upstream within the housing **3706** with the SCR **3704** located downstream of the heater **3702**. The heater **3702** may be configured to operate using the desired voltage (e.g., 6-45 amps) of the vehicle. When the lawnmower and/or another machine do not operate on a battery the heat may be supplied by the engine instead of using a heater.

The SCR **3704** like the selective catalytic reduction filtration systems discussed above, may be configured to reduce nitrogen oxide gases by oxidizing and converting them into harmless exhaust emissions that are emitted out of the exhaust system **3700** and into the environment with or without the need to introduce a liquid-reductant agent into the selective catalytic reduction filtration system **3704**. The selective catalytic reduction system **3704** includes a filter **3708** that may include, similar to the foregoing embodiments, a plurality of honeycomb shaped openings, may be coated with one or more noble metals **3710** (such as described above in FIG. **2**B), includes a plurality of rods **3712** formed of a metal or alloy that extend longitudinally through the honeycomb structure and one or more magnets **3714** arranged within the filter **3708**. The heater **3702**, rods **3712**, metal coating **3710** and magnets **3714** may operate similar to the function(s) as discussed above with regard to the exhaust systems of the foregoing embodiments of the present disclosure. Additionally or alternatively, the magnets **3714** may be arranged adjacent to the filters **3708** and/or external the housing **3706** of the exhaust system **3700**.

FIG. **38** depicts an exhaust system **3800** for a non-battery operated machinery that utilizes a fossil fuel. As shown, a selective catalytic reduction filtration system **3802**, which may or may not utilize a liquid-reductant agent, includes a filter **3804** that may be arranged within a housing **3803** and that may include a plurality of honeycomb shaped openings, may be coated with one or more noble metals **3806** (such as described above in FIG. **2**B), and may include a plurality of rods **3808** formed of a metal or alloy that extend longitudinally through the honeycomb structure and one or more magnets **3810** arranged within the filter **3804**. The rods **3808**, metal coating **3806** and magnets **3810** may perform substantially similar function(s) as discussed above with regard to the exhaust systems of the foregoing embodiments with the difference with respect to the exhaust system **3800** that the elements may not be heated within the housing **3803**. Additionally or alternatively to the placement of the one or more magnets **3810** within the filter **3804**, the magnets **3810** may be arranged adjacent to the filters **3804** and/or external to the housing **3803** of the exhaust system **3800**.

The embodiment shown in FIG. **39** illustrates an exhaust system for a power plant and steel plant or any similar plants having a smokestack, such as an exhaust system for a coal burning apparatus, device or the like. Those features shared with FIG. **34** will not be re-discussed here.

The new features of FIG. **39** include a coal burning and steel manufacturer and any other manufacturing facility that uses a smoke exhaust system **3100** having, among others, a dosing system that focuses on oxides of nitrogen (NOx) reduction capabilities to support application ranges from low to high flow selective catalytic reduction (SCR) dosing applications, and numerous other features of the smoke stack for reducing emission of sulfur dioxide (SO_2) and NOx from the power plant.

The dosing system may include, among other features, a dosing solution tank **003**, controller **001**, and a dosing solution injector **0035**. The dosing solution tank **003** may contain a dosing solution of, for example, urea, salt water, or ammonia, among other possible solutions. The dosing solution facilitates reduction of nitrogen oxides present in the system and is preferably injected as an aqueous reducing agent into the exhaust gas upstream of an SCR catalytic converter.

The dosing solution tank **003** includes a fill opening with cap and a pump **002** coupled to the controller **001**. The dosing solution tank **003** is not limited to any particular size, e.g., 500 gallons, 2000 gallons, or any desired size. The output of the pump is coupled to the dosing injector **0035**. The dosing injector **0035** may be an off the shelf injector to meet the system requirements or a custom designed injector based on the system requirements. The controller **001** may also include system wiring for power, data, and communications, although wireless coupling of the data and communication are also contemplated.

As previously described herein, one or more heaters may be added to the selective catalytic reduction (SCR) filtration system. Additionally, any added heater may be paired with a dosing injector **0035** at one or more of the locations such that the injected treatment solution passes through the heater. The coal burning exhaust system may also include at least one sensor, such as a gas temperature (heat) sensor or an O_2flow sensor. Other embodiments may have one or both of a gas temperature (heat) sensor or an O_2flow sensor at one or more of the locations. The output of each of these sensors is received by the control unit to determine the temperature of the heaters and/or the duty cycle of the injectors. The dosed treatment solution (e.g., dose) may be sent from the controller **001** through feeder line **09**, and dose overflow and air are bled through dose overflow line **08**. Likewise, the tank may have an overflow and air bleed line **008**, or similar pressure-control valve for controlling the flow of the dosed treatment solution.

As shown in FIG. **39**, the dosing injector **0035** provides dosing solution (e.g., urea, salt water or ammonia) to the heater which has been heated to a sufficient vaporizing temperature depending on the environment and system. The dosing solution is vaporized and thus produces steam into the system. This lowers the combustion temperature, which if low enough, reduces the concentration of thermal NOx formed. The temperature of the heater and the active time of the treatment solution injection may be monitored and controlled by the controller **001**. For example, the most efficient heater temperature would be from 400 degrees F. up to any desired temperature, such as a maximum of 1800 degrees F. For example, the active time of the dosing solution injection is typically one dose for every minutes. The number of injections may vary, including multiple dose injections depending on the system. The time may vary, including more or less than every 15 minute depending on the system. But the system will work at a lower or higher concentration.

Similar to the exhaust system of FIG. **34**, but with additions, FIG. **39** illustrates a plurality of filters **300**/**400**/**500** that include a honeycomb structures and chutes that direct unburned particles (e.g., coal) to a waste bin **4000** in which the unburned particles are disposed, an additional metal filtration system **400**, a second electric blower **601**, and a smoke stack through which clean gases exit into the environment.

The smoke stake of FIG. **39** may include a dual shell design to improve efficiency and environmental considerations. Specifically, the smoke stack of FIG. **39** includes an inner and an outer shell separated by gap in which fresh air is blown utilizing blower motor **39602** and fresh air feeder pipes **000**. This air passage cools the second (outer) shell of the smoke stack. The dual shell smoke stack may be defined by an inner stack **92** through which all the exhaust from the exhaust system is passed, and an outer shell **90** which is exposed on one side to the outside environment, as well as an air void **80** located between the inner stack **92** and outer shell **90** that allows fresh air to be blown there through keeping the outer shell **90** relatively cool to the environment. The inner shell may also include a heat pad **93** to assist in keeping the heat within the inner shell.

FIG. **40** shows a top view of the smoke stack and helps to illustrate the exhaust duct **4**, the heat pad **3** (**93**), the inner duct **1** (**92**), and fresh air opening **2** between the inner duct **1** and the outer duct. The inner duct **1** may be formed with steel as opposed to the more expensive brick construction. The heat pad **3** may include an aluminum backing and be installed to the inner duct **1** withstanding temperatures up to 2200 F or higher.

As noted above, the foregoing design eliminates the high cost of brick constructed smoke stack, which deteriorate over time. The inner duct **1** along with the heat pad **3** keeps the heat concentrate to the inside where the exhaust can continue to be processed. Furthermore, the fresh air gap before the second duct means the outwardly facing second duct is low temperature, safe to touch by environmental organisms (e.g., birds), has less mechanical upkeep, and does not deteriorate quickly due to large temperature fluctuations. For convenience, the following list identifies the features disclosed in FIG. **39** according to an embodiment of the invention:

001—controller
002—dose level controller and dose liquid pump to controller
003—dosing solution tank
008—overflow line and air bleeder
08—dose overflow line from dosing injector
09—feeder line
0035—dosing injector
12—heat sensor
10—wires (e.g., positive electrical connecter wires and negative)
79—main electrical box and safety box
400—SCR noble metallic coated SCR filter with a heater same time for NOx
300—ceramic noble metallic filter (e.g., serves same purpose as oxidation catalytic)
500—heated ceramic particular filter
13—heat sensor and safety sensor
39600—blower motor (e.g., variable blower motor)
14—steam and temperature sensor
25—electrical heater
26—SCR metallic catalytic converter system
27—particulate filter
28—NOx storage filter
010—negative electrical cable
3000—second filter housing
4000—dust and unburned coil dust collector
00—fresh air feeder pipes for the second opening of smoke duck
39601—second blower motor
39602—blower motor for the fresh air between the main smoke duck and second housing
89—first housing smoke duct opening
90—second outer shell smoke duct
80—between the 2-shell opening for fresh air blowers true to keep the outer shell cooler
93—heat pat (e.g., with aluminum backer installation to the first smoke duct)
7000—magnet(s)
8000—heat pad
9000—inner shell
0112—outer shell

For convenience, the following list identifies the features disclosed in FIG. **40**, which illustrates a top view of the smokestack shown in FIG. **40** according to an embodiment of the invention:

1—inner steel smoke duct housing

2—fresh air duct opening

3—heat pad with aluminum wrap (attached to the inner shell)

4—first body smoke duct housing opening

The foregoing description and accompanying drawings illustrate principles, exemplary embodiments, and modes of operation of the present invention. However, the present invention should not be construed as being limited to the particular embodiments disclosed herein. Variations to the embodiments discussed above will be appreciated by those skilled in the art without departing from the scope of the invention. Accordingly, the above-described embodiments and accompanying drawings should be regarded as illustrative rather than restrictive.

What is claimed is:

1. An assembly for improving an exhaust system comprising:

a heater configured to be coupled to a controller, the heater configured to be connected to the exhaust system to heat exhaust gases, the heater comprising:

a housing,

a connection pipe configured to connect the heater to a component of the exhaust system,

a heating element coupled to the controller,

a temperature sensor to detect a temperature inside the housing and transmit a corresponding signal to the controller, and

a dosing solution injector coupled to the temperature sensor via the controller, the dosing solution injector configured to spray a dosing solution inside the housing based on the transmitted signal to generate vapor to flow through the connection pipe to the component;

a magnet configured to be arranged adjacent to an exterior surface of the component to generate a magnetic field inside the component and aid in disruption and slowing of a flow of the exhaust gases in the component; and

a second heater arranged to heat the exhaust gases prior to the exhaust gases flowing through an inlet port of the component or after the exhaust gases have passed through an outlet port of the component.

2. The assembly of claim **1**, wherein the component is one or more of the following: a catalytic converter, a diesel oxidation catalyst, a diesel particulate filter (DPF), and a selective catalytic reduction system (SCR).

3. The assembly of claim **1**, wherein the component is two or more of the following: a catalytic converter, a diesel oxidation catalyst, a diesel particulate filter (DPF), and a selective catalytic reduction system (SCR).

4. The assembly of claim **1**, further comprising a dosing solution reservoir that houses the dosing solution and is coupled to the dosing solution injector.

5. The assembly of claim **1**, further comprising a dosing solution distributor located downstream of the dosing solution injector and configured to distribute the dosing solution spray, sprayed by the dosing solution injector.

6. The assembly of claim **1**, further comprising a gas sensor configured to be coupled to the component to transmit a corresponding signal to the controller.

7. The assembly of claim **1**, wherein the controller is a dedicated controller configured to control the assembly.

8. The assembly of claim **1**, wherein the heating element is a heating wire.

9. The assembly of claim **1**, wherein the second heater comprises:

a second heater housing;

a first terminal and a second terminal configured to be electrically coupled to a power supply via an exterior of the second heater housing;

a heating wire coupled to the first and second terminals;

a filter affixed within the second heater housing; and

a plurality of heating rods inserted through one or more openings in the filter, the heating rods configured to conduct heat from the heating wire to the filter, at least one of the heating rods to support the heating wire disposed outside of the filter, wherein the plurality of heating rods are configured to conduct heat from the heating wire to the filter.

10. The assembly of claim **9**, wherein the second heater is configured to receive first signals from the controller to control an amount of current supplied to the second heater and a timing in which the current is supplied to the second heater, whereby the supplied current and the timing are based on one or more sensors located within the exhaust system or the second heater.

11. The assembly of claim **9**, wherein one or more of the plurality of heating rods extend through two ends of the filter.

12. The assembly of claim **9**, wherein the second heater housing includes a second heating wire displaced from the heating wire.

13. The assembly of claim **12**, wherein the heating wire and the second heating wire are displaced in two parallel planes.

14. The assembly of claim **9**, wherein one or more of the plurality of heating rods comprise a rod portion and a tip portion.

15. The assembly of claim **14**, wherein the one or more tip portions are formed at ends of one or more of the plurality of the heating rods.

16. The assembly of claim **15**, wherein the one or more tip portions are configured to conduct heat from the heating wire to the filter.

17. The assembly of claim **16**, further comprising: one or more fasteners disposed at the one or more tip portions, the fastener configured to support the heating wire.

18. The assembly of claim **17**, wherein the one or more fasteners are formed of an insulative material such that electrical current does not transfer from the heating wire to the heating rod.

19. The assembly of claim **9**, wherein the heating rods comprise at least two lengths.

20. The assembly of claim **1**, further comprising a second temperature sensor to detect a temperature in the component and transmit a corresponding signal to the controller, wherein the controller is configured to transmit a signal to the dosing solution injector to spray the dosing solution when a predetermined temperature in the component is detected.

21. A method for installing an assembly for improving an exhaust system comprising:

attaching a heater configured to be coupled to a controller, the heater configured to be connected to the exhaust system to heat exhaust gases, the heater comprising:

a housing,

a connection pipe configured to connect the heater to a component of the exhaust system,

a heating element coupled to the controller,

a temperature sensor to detect a temperature inside the housing and transmit a corresponding signal to the controller, and

a dosing solution injector coupled to the temperature sensor via the controller, the dosing solution injector configured to spray a dosing solution inside the housing based on the transmitted signal to generate vapor to flow through the connection pipe to the component;

attaching a magnet configured to be arranged adjacent to an exterior surface of the component to generate a magnetic field inside the component and aid in disruption and slowing of a flow of the exhaust gases in the component; and

attaching a second heater to heat the exhaust gases prior to the exhaust gases flowing through an inlet port of the component or after the exhaust gases have passed through an outlet port of the component.

22. The method of claim **21**, wherein the exhaust system is a vehicle exhaust system, and the component is one or more of the following: a catalytic converter, a diesel oxidation catalyst, a diesel particulate filter (DPF), and a selective catalytic reduction system (SCR).

23. The method of claim **21**, wherein the second heater comprises:

a second heater housing;

a first terminal and a second terminal configured to be electrically coupled to a power supply via an exterior of the second heater housing;

a heating wire coupled to the first and second terminals;

a filter affixed within the second heater housing; and

a plurality of heating rods inserted through one or more openings in the filter, the heating rods configured to conduct heat from the heating wire to the filter, at least one of the heating rods to support the heating wire disposed outside of the filter, wherein the plurality of heating rods are configured to conduct heat from the heating wire to the filter.

24. The method of claim **23**, wherein the second heater is configured to receive first signals from the controller to control an amount of current supplied to the second heater and a timing in which the current is supplied to the second heater, whereby the supplied current and the timing are based on one or more sensors located within the exhaust system or the second heater.

25. The method of claim **21**, further comprising a second temperature sensor to detect a temperature in the component and transmit a corresponding signal to the controller, wherein the controller is configured to transmit a signal to the dosing solution injector to spray the dosing solution when a predetermined temperature in the component is detected.

26. A method for improving an exhaust system comprising:

receiving, at a heater, a current in response to a signal from a controller;

generating heat, via the heater, inside a component of the exhaust system;

injecting, via a dosing solution injector, a dosing solution into the heater;

generating, by the heater, a vapor comprising the dosing solution;

directing, by the heater, the vapor into the component;

generating, by a magnet, a magnetic field inside the component;

disrupting and slowing, by the magnet and magnetic field, an exhaust gas flow in the component; and

generating heat, via a second heater arranged within the exhaust system to heat the exhaust gases prior to the exhaust gases flowing through an inlet port of the component or after the exhaust gases have passed through an outlet port of the component.

27. The method of claim **26**, wherein the heater comprises a plurality of heating elements.

28. The method of claim **27** further comprising:

generating, by a heat sensor, a temperature signal corresponding to a temperature of the heater;

transmitting, by the heat sensor, the temperature signal to the controller; and

receiving, by the heater, a second current based on the temperature signal.

29. The method of claim **28** further comprising:

generating, by a gas sensor, a gas signal corresponding to a composition of the exhaust gas flow within the component;

transmitting, by the gas sensor, the gas signal to the controller; and

receiving, by the heater, a third current based on the gas signal and the temperature signal.

30. The method of claim **29** further comprising:

generating, by a second gas sensor, a second gas signal corresponding to a second composition of the exhaust gas flow within a second component;

transmitting, by the second gas sensor, the second gas signal to the controller; and

receiving, by the heater, a fourth current based on the gas signal, the second gas signal, and the temperature signal.

31. The method of claim **26**, wherein the second heater comprises:

a second heater housing;

a first terminal and a second terminal configured to be electrically coupled to a power supply via an exterior of the second heater housing;

a heating wire coupled to the first and second terminals;

a filter affixed within the second heater housing; and

a plurality of heating rods inserted through one or more openings in the filter, the heating rods configured to conduct heat from the heating wire to the filter, at least one of the heating rods to support the heating wire disposed outside of the filter, wherein the plurality of heating rods are configured to conduct heat from the heating wire to the filter.

32. The method of claim **31**, wherein the second heater is configured to receive first signals from the controller to control an amount of current supplied to the second heater and a timing in which the current is supplied to the second heater, whereby the supplied current and the timing are based on one or more sensors located within the exhaust system or the second heater.

33. The method of claim **26**, further comprising a second temperature sensor to detect a temperature in the component and transmit a corresponding signal to the controller, wherein the controller is configured to transmit a signal to the dosing solution injector to spray the dosing solution when a predetermined temperature in the component is detected.

* * * * *